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# HIGH EXPLOSIVES

**First Section**

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**Manufacture, Handling,  
Storage and Use**

**T**HIS HIGH EXPLOSIVES HANDBOOK  
is printed in two sections, this being Section 1.

Section 2 covers kinds, grades and brands of  
Du Pont High Explosives.

Should you not already have Section 2, a  
copy will be sent on request.

**E. I. DU PONT DE NEMOURS  
& COMPANY**

**WILMINGTON**

**DELAWARE**



# HIGH EXPLOSIVES

Their Manufacture, Storage,  
Handling and Use

First Section

E. I. du Pont de Nemours & Company  
Established 1802 Wilmington, Delaware

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E. I. du Pont de Nemours & Company  
Wilmington, Delaware

## *Preface*

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FEW people realize to how great an extent modern progress is dependent upon the use of explosives. People are accustomed to associate dynamite in their minds with bombs, riots, outrages and crimes of various kinds. The fact may not occur to them that where ounces of explosives are used illegitimately, millions and millions of pounds are doing necessary and useful work. Every modern building, for instance, represents tons of explosives used, in mining the iron ore from which structural steel is made, quarrying the rock from which cement is made, mining coal to generate the power and heat for making the steel and cement, constructing the roads and canals and deepening the channels through which all these materials are transported.

Iron and steel for every kind of machinery, copper for all kinds of electrical apparatus, lead for the manufacture of paints, zinc for galvanizing sheet iron, and silver and gold are all mined with explosives.

No coal, whether bituminous or anthracite, can be mined economically without the use of explosives. Graphite for pencils, rock salt for freezing ice cream, talc for face powders, gypsum for wall plaster, lime for mortar, broken stone for building roads—all these things and many more are absolutely dependent for their economical production upon the use of explosives. The farm and orchard have become consumers of explosives in large and increasing quantities.

Industries as we know them now, without explosives would come instantly to a standstill. This is no stretch of the imagination, but a cold, hard fact. Explosives are necessary tools of civilization.

**THE SIGN OF QUALITY**



**YOUR SAFEGUARD IN  
BUYING EXPLOSIVES**

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THE LARGEST HIGH EXPLOSIVE PLANT IN THE WORLD. THE DU PONT COMPANY'S REPAUNO WORKS, LOCATED AT GIBBSTOWN, N. J. (P. R. R.); THOMPSON'S POINT, N. J. (P. & R.)

# HIGH EXPLOSIVES

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THE term "High Explosives," as applied to blasting compounds, includes all of those explosives which can be properly detonated only by the means of an intermediate agent, such as a blasting cap or electric blasting cap, and not by simple ignition.

High explosives differ from low explosives (blasting powder, etc.), in that they explode with much greater rapidity, and, except in the case of Permissible Explosives, have more of a shattering effect. Blasting gelatin, the Permissible Explosives and the various kinds of dynamite are examples of commercial high explosives.

Many different properties contribute to the effectiveness of high explosives, the most important of these being: *strength or disruptive power, and quickness or shattering power*. Other principal factors in the usefulness of high explosives are stability or keeping qualities, and those qualities which tend to make them safer to handle. These essentials can only be secured and maintained by the employment of the highest quality of ingredients, greatest care and attention, expensive and complicated machinery, skillful labor and supervision, and long experience and continual testing.

The Du Pont Company began the manufacture of explosives in this country in 1802 and to-day has mills and factories in all parts of the United States, one of these being the largest dynamite factory in the world. No other manufacturing concern in this country maintains a greater number of technical chemists than are engaged at the Du Pont laboratories. These chemists are employed in testing daily the output of the factories to prevent any deviation from standards, and in studying and experimenting with explosives in order to improve them.

A corps of experts in the use of explosives is also maintained, whose duty is; first, to make a study of the exact requirements of explosives in the various fields and under the widely differing conditions where they can be used to advantage, and to report to the chemical staff what these requirements are; second, to test out



FIRST DU PONT OFFICE BUILDING

thoroughly such explosives when they have been produced, these tests being made in mines and quarries under every possible condition and usually requiring several months' time; and third, to instruct consumers in the use of explosives, explaining and demonstrating the qualities and action of the different kinds. Although this system is so expensive that only the great quantity of explosives which we sell warrants it, experience has taught us that it is the only way to maintain the highest quality in our explosives, to furnish customers promptly exactly what they need to insure maximum results at a minimum expense, and in every way to maintain our position as the leading explosives manufacturers of the world.

The great improvement brought about in recent years by the Du Pont Company in the reliability, efficiency and stability of explosives, whereby they have become comparatively safe to handle, give maximum results in blasting, and can be kept under proper conditions for long periods without deteriorating, is responsible for their general use, and has made it possible to dig canals, build railroads and mine low-grade ores to an extent which otherwise would have been out of the question. Other improvements, such

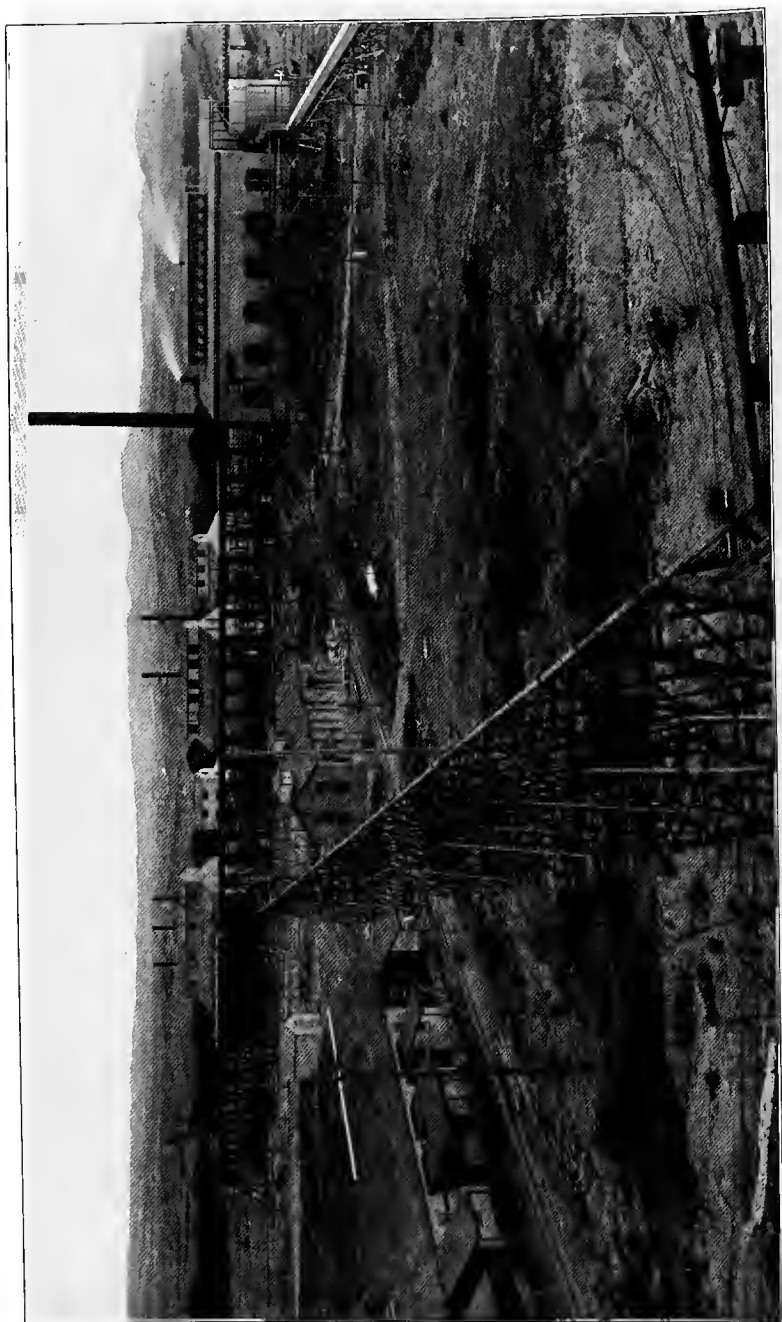


PRESENT DU PONT OFFICE BUILDING

as a wide distribution of production and storage points, making it possible to deliver explosives promptly to any part of the United States, and the production of a specially adapted explosive for almost every different kind of work, together with detailed instructions in regard to its use, have brought about the employment of explosives in so many new fields and for so many new purposes that almost all progress is now largely dependent, either directly or indirectly, upon them.

### PROPERTIES OF HIGH EXPLOSIVES

The properties of high explosives which are of first importance to the user are those upon which depend, either directly or indirectly, their strength, quickness, sensitiveness, resistance to cold, fumes evolved and resistance to water. These differ in the order of importance according to the kind of work in which the explosive is used, and the qualities most desirable in one kind of work may be of little value, or actually harmful, in another. It is necessary, therefore, to manufacture explosives with specific characteristics for different classes of work, and it is a great mistake for the consumer



POWER HOUSE AND ACID PLANT, LOUVIERS, COLORADO HIGH EXPLOSIVE WORKS

to buy explosives regardless of their special qualities and without knowing positively just what kind of an explosive would be most economical for the work to be done.

A large proportion of the complaints arising from supposed failure of explosives to do the work desired is due, not to any inherent defect in the explosive itself, but in the fact that it is not suited for that class of work. Instances where customers use a high-grade gelatin for mudcapping; or explosives of the permissible type for open work; or quarry powder and other kinds of quick, shattering explosives for soil and close work; or slow acting explosives in brittle rock, are examples of what may be termed, "explosive misfits."

The gelatin explosives are not quick acting enough for mudcapping. Permissibles are designed primarily for coal mining and produce a relatively low temperature, flame of short duration and very little objectionable smoke or fumes. Quarry powders are made so as to be as strong and quick as possible without regard to their fumes; and a particular character of rock may resist the action of a quick powder, while a slow acting powder in it would give the desired results. No one explosive can be made which combines the desirable properties of all of them, although some varieties have a wider range of application than others.

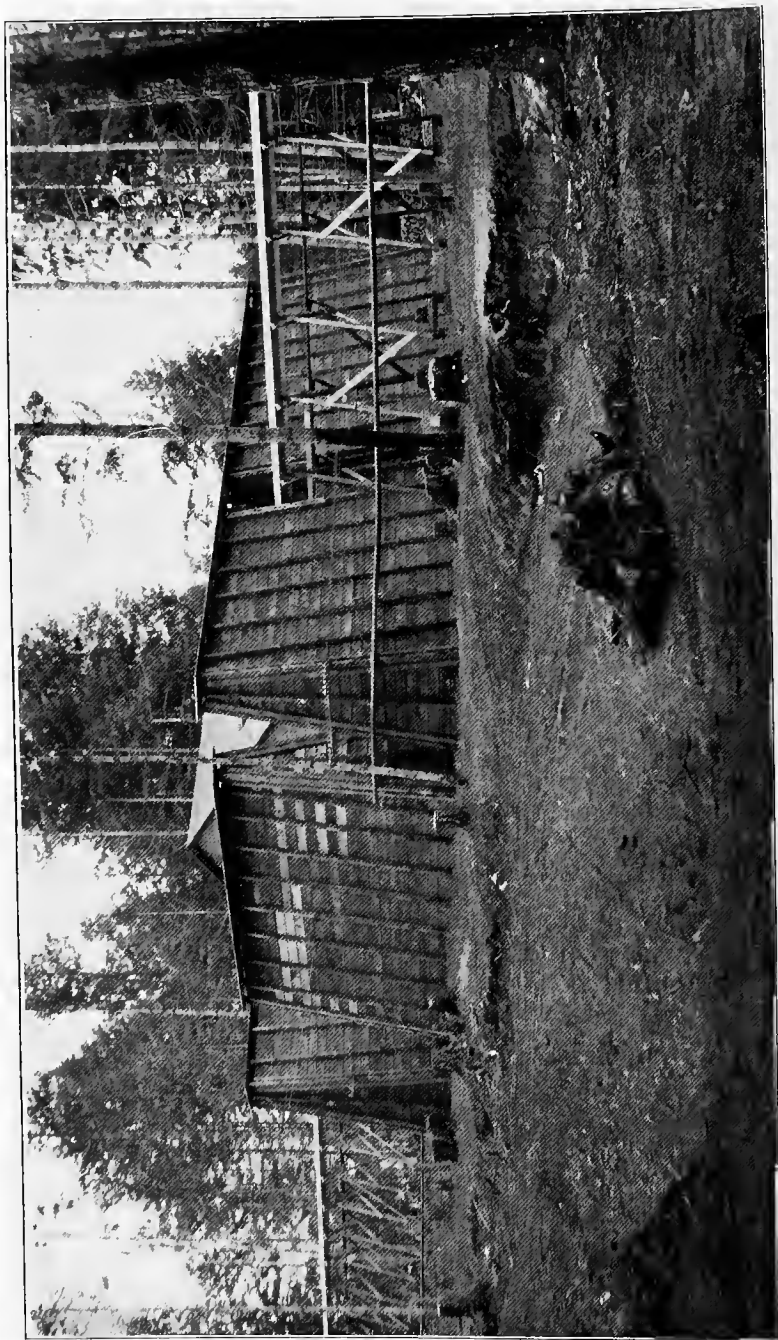
It is, of course, not expected that the consumer should be fully conversant with the exact properties of each of the many kinds of high explosives which we manufacture. For this reason we maintain a corps of experts in the use of explosives and will, when requested, send one of them to look over the work of our customers and advise them what explosives should be used and the most economical manner of using them.

### **WORD "DANGER" ON EVERY CARTRIDGE**

In line with its established policy of promoting safety in the use of our explosives, the Du Pont Company prints the word "DANGER" prominently on every cartridge of dynamite made by them.

In doing this our aim is to protect all as far as possible, and particularly those not familiar with the appearance of a dynamite cartridge nor the precaution to be observed in handling it.

Such marking does not mean that our dynamites are any more dangerous than heretofore or more dangerous than competitive explosives not so marked.



SEPARATING HOUSE, DU PONT, WASHINGTON HIGH EXPLOSIVES WORKS

The millions of pounds of our dynamites used without accident testify to our constant effort to increase their safety.

Such marking, we feel, will promote careful handling because it will indicate to the general public as well as the regular user that there is an element of danger in handling cartridges of explosives carelessly.

## FUMES EVOLVED WHEN DETONATED

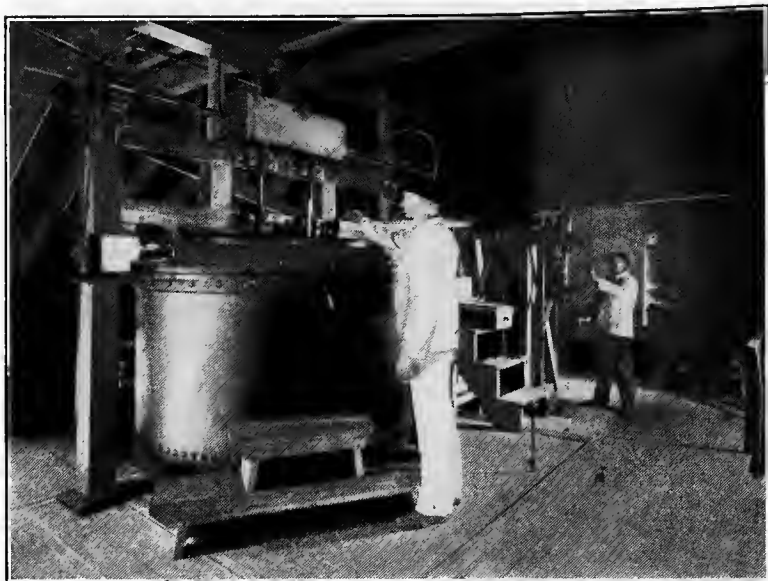
The Du Pont Company fully recognizes the important influence on mining of the fumes given off by the detonation of explosives, and particular attention is given to this point in their preparation. As the efficiency of an explosive depends directly on the volume of gas evolved, the end aimed at is not to reduce the quantity of gas given off, but to make the explosive of ingredients which, combined in the *proper proportions*, will reduce to a minimum *objectionable* gases.

When a charge of high explosives is imperfectly detonated, or detonated without being properly tamped, the volume and composition of the gases given off may be very different from what they would be were a sufficiently strong detonator used and the bore hole tamped as it should be. In developing the formula for an explosive, it must be assumed that the detonation will be complete, and the detonator to be used with that explosive is always specified. If, then, a weaker detonator than that which we recommend be used, or the bore hole be insufficiently tamped, not only will the volume of gas generated by the explosion be smaller, resulting in inferior execution, but the gases may be very obnoxious or even dangerous to workmen and draft animals. Instances have been known in underground work where workmen have been killed by the poisonous gas evolved by the imperfect or incomplete detonation of explosives. This same trouble may occur in a limited degree when an explosive is used in work for which it is not intended, as for instance, when an explosive designed for outside work is used underground, or one designed for dry work is used where water is present.

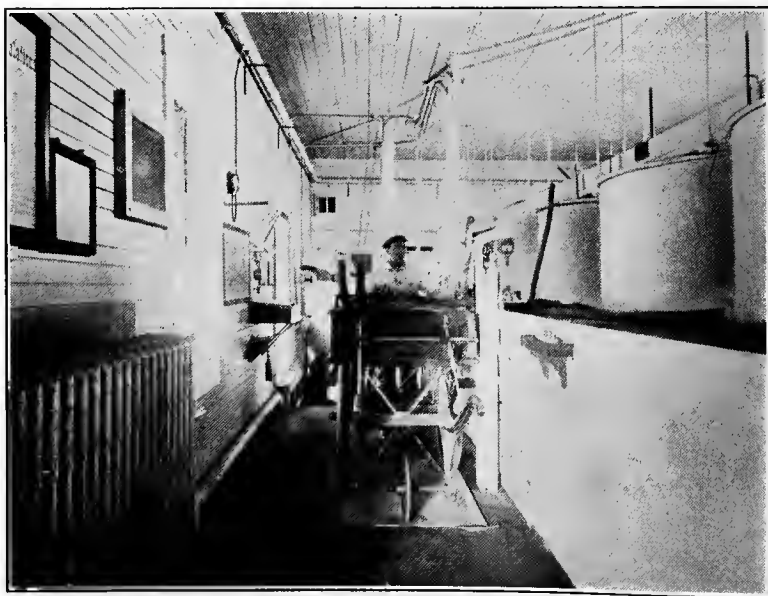
## MANUFACTURE OF HIGH EXPLOSIVES

The high explosives generally used in blasting operations consist of a mixture of nitroglycerin or other primary explosive ingredient, an absorbent to carry the liquid explosive, such as wood pulp, and an oxygen-bearing salt, such as nitrate of soda.

Their manufacture involves not only the mixing of the prin-



NITROGLYCERIN HOUSE. HERE THE GLYCERINE IS MIXED WITH ACID IN THE COOLED STEEL TANK, MAKING NITROGLYCERIN



NITROGLYCERIN STOREHOUSE, WHERE THE NITROGLYCERIN IS ACCURATELY WEIGHED BEFORE WHEELING IT TO THE MIXING HOUSE

cial ingredients and packing them for shipment, but also the preparation of the various ingredients used.

The nitroglycerin operation is perhaps the most important on a High Explosive plant, and involves the nitration of glycerin by the use of a nitric and sulphuric acid mixture. These acids may either be made on the plant or purchased from regular manufacturers.

Sulphuric acid is manufactured by a number of processes, all of which involve the production of sulphur dioxide gas from sulphur or sulphur-bearing materials, the conversion of the sulphur dioxide gas to sulphur trioxide and the absorption of this gas in water.

Nitric acid is usually produced by the decomposition of nitrate of soda with sulphuric acid, the gas formed by this treatment being condensed and forming liquid nitric acid.

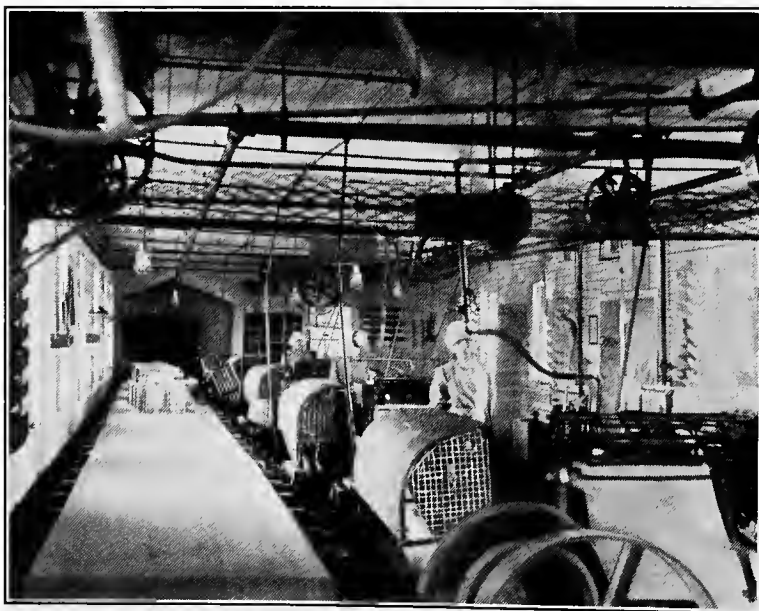
In the manufacture of nitroglycerin, sulphuric and nitric acids are mixed in the proper proportions and commercial refined glycerin, ordinarily sold as "dynamite glycerin," is treated with this acid mixture to produce nitroglycerin with proper provisions to absorb the heat of reaction. The nitroglycerin is allowed to separate from the acid mixture and is subsequently purified and neutralized. After the separation of the nitroglycerin, the acids are separated from each other, concentrated and again used.



TRANSPORTING LIQUID NITROGLYCERIN TO DYNAMITE MIXING HOUSE



MIXING HOUSE, WHERE THE NITROGLYCERIN IS THOROUGHLY INCORPORATED  
WITH AN ABSORBENT TO MAKE DYNAMITE



WHERE THE PAPER SHELLS ARE MADE INTO WHICH DYNAMITE IS LOADED.  
THE LOADED SHELLS ARE KNOWN AS CARTRIDGES

After purification, the nitroglycerin is mixed with an absorbent and other materials, properly proportioned, to form ordinary dynamite, or if gelatin dynamite is to be produced, the nitroglycerin is gelatinized with gun cotton before mixing with the other ingredients. The proportion of nitroglycerin and other materials is varied in accordance with the uses for which the explosives are intended. After mixing, the dynamite or gelatin is packed in paper cartridges and subsequently in wooden boxes in which it is delivered to the trade.

While the foregoing covers the essential steps in the preparation of High Explosives, the scientific work of the past few years has taught the progressive manufacturer how to modify his operations so as to obtain in the finished explosive the characteristics that are necessary to give satisfactory service under various climatic conditions and variety of material to be blasted. To accomplish these a very elaborate equipment and the closest attention to details is required.



PACKING THE CARTRIDGES INTO WOODEN CASES READY FOR THE MARKET



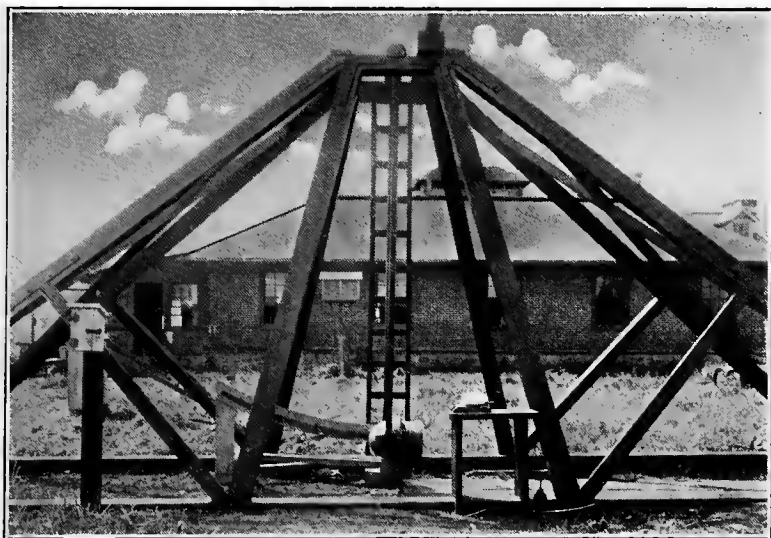
HEADQUARTERS, DU PONT EASTERN LABORATORY, GIBBSTOWN, N. J.

## TESTING DU PONT HIGH EXPLOSIVES

Experimental and testing work are important features at every Du Pont plant.

One vital factor in making a successful product is to see that the raw materials that go into it are right. This feature is given the strictest attention at all Du Pont plants, all materials being rigidly inspected and tested, and any not coming up to the high Du Pont standard being rejected.

While in the course of manufacture Du Pont high explosives are subjected to continual tests, nothing is left to chance. The completed product is finally tested most carefully before it is allowed to go on the market.

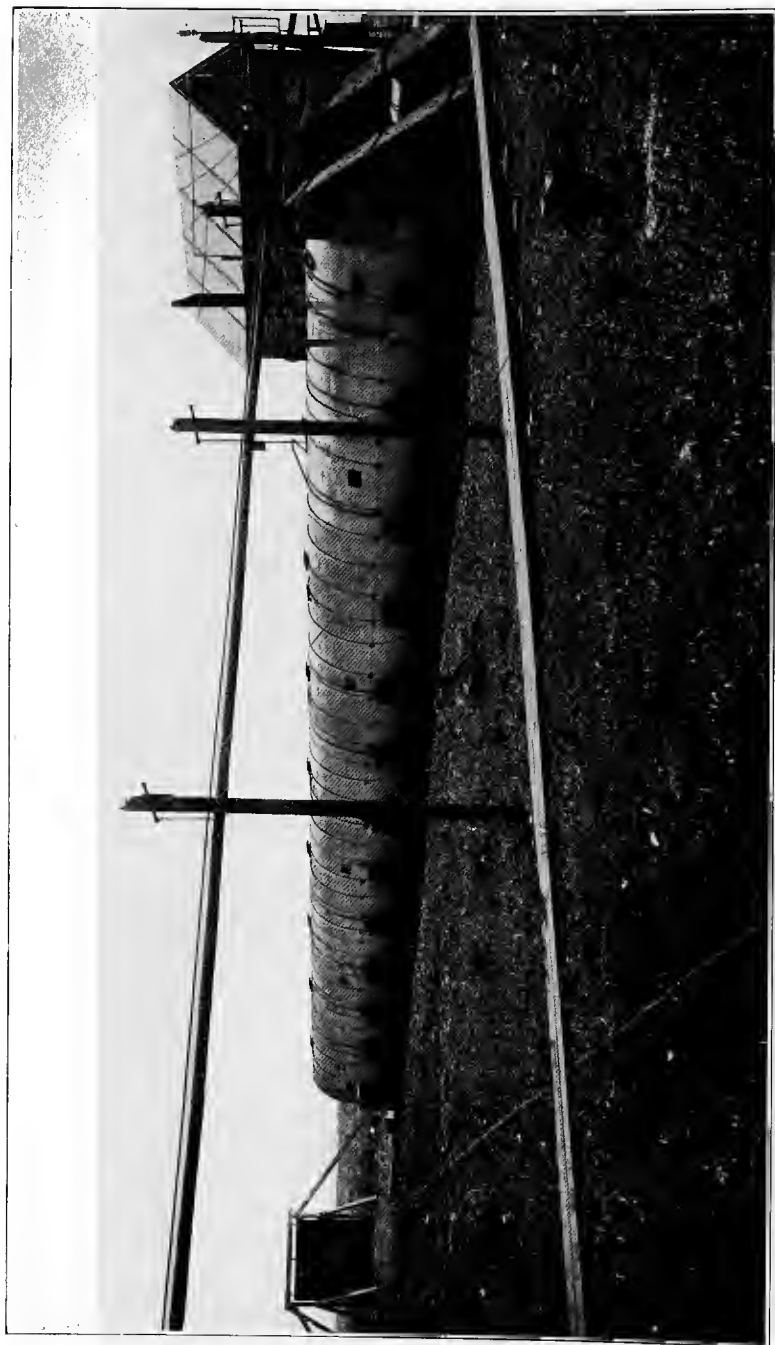


BALLISTIC PENDULUM, USED FOR MEASURING STRENGTH OF HIGH EXPLOSIVES

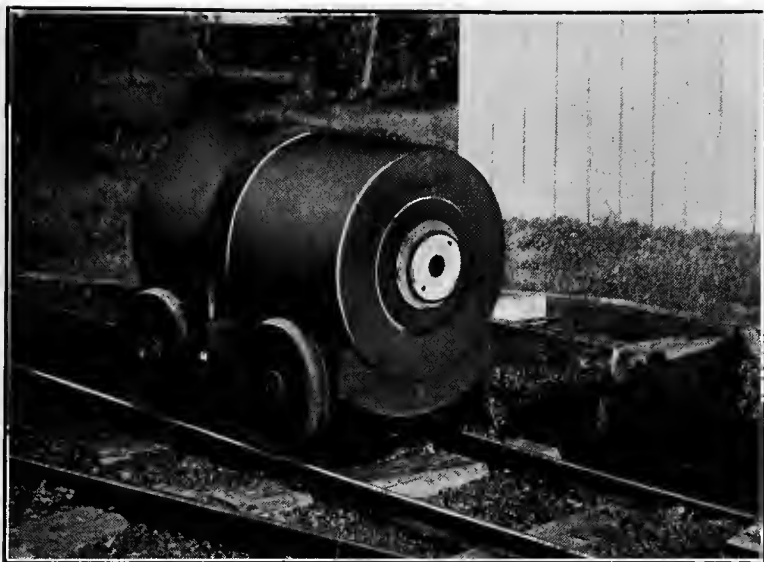
At each of our works we have completely equipped laboratories manned by skilled chemists, men who by their education, training and experience in the manufacture and use of high explosives, have qualified as experts in their chosen field.

The various testing apparatus used by this Company embody many unique and valuable features, invented by our own men.

When you buy and use Du Pont high explosives, you have the assurance that no detail has been neglected which would, in the slightest way, tend to bring about perfection of result.



DU PONT TESTING GALLERY, REPAUNO, N. J., USED IN TESTING DU PONT PERMISSIBLE EXPLOSIVES



STEEL MORTAR USED AT THE EASTERN LABORATORY FOR TESTING PERMISSIBLE  
EXPLOSIVES



MACHINE AT THE EASTERN LABORATORY FOR RECORDING THE PRESSURE DEVELOPED BY THE DETONATION OF HIGH EXPLOSIVES



REPAUNO WORKS. STEAMER AT PIER ON DELAWARE RIVER UNLOADING NITRATE OF SODA

# HANDLING HIGH EXPLOSIVES

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## GENERAL REMARKS

If high explosives are handled sensibly and with due regard to their properties, they can be handled with comparative safety, but with some consumers familiarity is too apt to breed contempt, with injury or death as the result. During every stage of their production, those engaged in the manufacture of high explosives handle them with the greatest caution and respect; but frequently they have hardly come into the possession of the consumer when they are knocked about, thawed around open fires, the cases opened with a pick, the sharp point of a rock, or by dropping on the ground, etc. The Du Pont Company desires to impress the consumer with the fact that carelessness in the handling of explosives is always dangerous and liable to be very expensive. The man who handles dynamite roughly or carelessly, perhaps with the desire to "show off," is not a competent blaster, but a menace and peril to all. A thorough observance of the "Don'ts" in the back of this book will minimize the liability of accidents from explosives.

Interstate Commerce Commission Regulations for Transportation of Explosives, copies of which can be procured from the Bureau of Explosives, Underwood Building, New York City, must be complied with by all persons shipping explosives.

Federal Law—An act of Congress of March 4, 1909, effective January 1, 1910, Sections 232, 233, 234, 235, 236 and 345 provides:

That it is a criminal act to carry, or cause to be carried, any explosives (other than exceptions named) on any train, boat, trolley or other vehicle carrying passengers for hire ; or

To deliver, or cause to be delivered, to a common carrier for transportation, any explosive under false or deceptive marking or description, of package, invoice or shipping order ; or

To violate or cause to be violated any regulation of the Interstate Commerce Commission relating to marking, shipping or handling of explosives.

Violations are punishable by—

Fine of not more than \$2,000 or imprisonment for not more than eighteen months, or both;

Or if death or injury results from violations,

By imprisonment for not more than ten years.

Therefore, persons engaged in handling, shipping or delivering explosives should understand that they are personally liable to the above penalties and no instructions should be followed which will cause a violation of the above act or the Interstate Commerce Commission Regulations.

## GENERAL RULES

The following precautions should always be observed in shipping, storing, handling or delivering explosives or while near explosives:

A competent person should always be in charge of explosives, magazines in which explosives are stored, keep magazine keys, and be responsible that all proper safety precautions are taken.

If artificial light is needed use only an electric flash light or electric lantern. Do not use oil burning or chemical lamps, lanterns, candles or matches.

Keep constant watch for broken, defective or leaky packages.

Do not allow metal bale hooks or other metal tools to be used.

Do not open or re-cooper packages with metal tools.

Do not use empty high explosive cases.

Do not throw packages of explosives violently down or slide them along floors or over each other, or handle them roughly in any manner.

In shipping, storing, handling, or using explosives comply with Interstate Commerce Commission Regulations, State laws, city and other local ordinances.

Exercise extreme care in handling, transporting and storing all explosives.

## TRANSPORTING EXPLOSIVES

The American Railway Association Rules and the Interstate Commerce Commission Regulations for the Transportation of Explosives are very complete codes of instructions covering in detail the directions which must be followed in shipping each kind of explosive. Diagrams showing the proper way to load cars are furnished, and railroads will not accept shipments unless all conditions have been complied with. A copy of these rules can be secured from railroad agents.

When transporting explosives by team always keep the wagon boxes thoroughly swept out, and when using an open wagon protect the load from the sun's rays, rain, etc., with a canvas covering. Store the cases of explosives so that they will not shift and *never haul detonators and explosives together.*

In transporting explosives avoid all unnecessary stops. Do not haul through cities, towns or villages when possible to avoid it, but where this is necessary keep off congested thoroughfares, street-car tracks and dangerous crossings.

Do not leave any vehicle containing explosives unless team is securely tied and brakes set, or if motor truck is used, motor should be stopped and brakes set.

Do not carry blasting caps or electric blasting caps on a vehicle containing other explosives.

Do not carry metal tools on a vehicle transporting explosives.

When explosives are on vehicles without tops they should always be protected from sun and weather by a tarpaulin.

Vehicles and harness used for transporting explosives should always be kept in first-class repair. Do not run any risk of vehicles or harness breaking down.

#### UNLOADING CARS OF EXPLOSIVES

Cars should be unloaded promptly in compliance with the Interstate Commerce Commission regulations.

When cars are opened retain all seals and take record of seal numbers.

Cars containing explosives should be securely locked or guarded when not being loaded or unloaded. To prevent fire, all leaves, grass, trash and debris should be removed to a safe distance from cars.

In loading or unloading explosives, great care must be taken to prevent sparks from passing locomotives falling in vehicle. Car doors facing parallel track should be kept closed at all times. When unloading in railroad yards, with parallel tracks on both sides of car, keep doors closed when locomotives are passing or are within 100 feet of the car.

In unloading cars comply with the requirements of cards tacked on inside of cars.

Where an inclined chute is used it must be constructed of 1-inch planed boards, with side guards 4 inches high extending 3 inches above top face of bottom of chute and throughout its length, fastened with brass screws. "D" shaped strips or runners, not more than 6 inches apart, and running lengthwise of chute, must be fastened to the upper surface of the bottom board by means of glue and wooden pegs extending through the bottom board and runners. Chutes may be occasionally wiped down with waste moistened with machine oil, but care should be taken that all surplus oil is removed to prevent staining the dynamite cases. A stuffed mattress, 4 feet wide by 6 feet long and not less than 4 inches thick, or a heavy jute or hemp mat of like dimensions must be placed under the discharging end of chute. (Interstate Commerce Commission Regulations.)

Where explosives are being handled between the floor of a magazine and the floor of a car, if runway is used it should have no exposed metal. All nail heads, bolts or screws must be countersunk and there should be no metal bands around the ends.

Don't place explosives on the ground.

If any packages of high explosives are received in leaky or damaged condition, put packages to one side in magazine and make full report in detail to us, giving probable cause of damage.

All placards should be removed from cars after explosives have been unloaded.

After unloading car containing blasting powder, car should be swept out and sweepings destroyed by throwing in water.

Notify railroad company as soon as cars are unloaded.

#### STORING EXPLOSIVES

All high explosives should be stored only in fire-proof, bullet-proof and weather-proof magazines, properly ventilated.

Blasting powder may be stored with high explosives if the magazine is bullet-proof, fire-proof and weather-proof and properly ventilated.

Blasting caps and electric blasting caps should be stored in fire-proof and weather-proof magazines, properly ventilated.

Blasting caps and electric blasting caps should never be stored in the same magazine with any other explosives.

Keep the door of a magazine securely locked when not engaged in the magazine.

Keep ground around magazines clear of leaves, grass, trash, stumps or debris to prevent fire reaching them.

If leak develops in magazine roof or walls, repair it at once.

Always ship, deliver or use oldest stock first.

When blasting powder and dynamite are both stored in one magazine, store each explosive separately.

Dynamite boxes should be laid flat, top side up. Corresponding grades and brands should be stored together and in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be delivered or used first.

Always be on the lookout for dynamite cases showing stains of any nature caused by leakage of any substance from within the case, and report it immediately.

Magazine floors should be regularly swept and kept clean. Destroy sweepings from dynamite magazine floors by burning.

In case magazine floors become stained with nitroglycerin, scrub well with a stiff broom, hard brush or mop with a solution composed of one-half gallon water, one-half gallon wood alcohol and two pounds sulphide of sodium. Use plenty of the liquid so as to thoroughly decompose the nitroglycerin.

When magazines require any repairs on the inside of the building, all explosives should be removed to a safe distance and protected. If dynamite has been stored in the magazine and there are any indications of nitroglycerin stains on the floor, wash this portion of the floor before the repairs are undertaken, as instructed in preceding paragraph. In case the floor is badly stained, notify us. In making outside repairs, if there is any possibility of causing a spark, fire or explosion, the explosive should be removed to a safe distance from the magazine and properly cared for until the repairs are made. While magazines are being repaired, explosives should be protected from the weather. Don't store them on the ground.

Use a wooden wedge and mallet in opening or closing packages of explosives.

Do not have loose dynamite or blasting supplies exposed in any magazine.

Do not pile damaged or unsalable explosives with salable stocks.

Do not keep or use any steel or metal tools in a magazine, or store any commodity except explosives in a magazine.

Do not store any explosives where they are likely to get wet or absorb moisture.

Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.

Do not leave explosives lying around where children or people can meddle with them. Always keep them under lock and key in a suitable magazine.

Do not store fuse in a hot place. Fuse should be kept cool and dry.

Do not store any explosives in a dwelling, blacksmith shop, barn or in any place where in event of an accident loss of life or property damage might result.

Don't use a magazine for a thawing house.

Don't store primed cartridges in a magazine; *i. e.*, cartridges with detonator attached.

Post magazine rules in every magazine and comply with them.

### **DESTROYING UNSALABLE EXPLOSIVES**

Whenever it becomes necessary to destroy damaged explosives, immediately communicate with us for advice and instructions.

### **REPACKING EXPLOSIVES**

When repacking is required or deemed necessary in order to comply with Interstate Commerce Commission Regulations, communicate with the Explosives Bureau, 30 Vesey Street, New York City, for advice and instructions.

### **SHIPPING EXPLOSIVES**

Railroad must be given twenty-four hours' notice of all less than carload shipments, and their destination.

Comply with Interstate Commerce Commission's latest regulations. Do not offer for rail shipment explosives that violate Interstate Commerce Commission Regulations.

Interstate Commerce Commission Regulations prohibit the shipment of blasting caps and electric blasting caps in cars containing high explosives.

Cars used for transportation of explosives must be certified, inspected and placarded in accordance with the Interstate Commerce Commission Regulations.

Condition of shipments must comply with the Interstate Commerce Commission Regulations for transportation and must be packed, marked, loaded, stowed and handled in accordance with the Interstate Commerce Commission Regulations.

In reshipping original packages to the trade, former markings and addresses must be removed or obliterated.

Name of consignee, destination, county and state must be plainly marked or stenciled on all packages for shipment. Don't use tags or stickers.

When necessary to ship less than original packages of blasting supplies, such packages, packing and markings must comply with Interstate Commerce Commission Regulations.

Bills of lading covering all shipments of explosives must conform in every detail to the Interstate Commerce Commission Regulations.

Shippers' certificates, as required by the Interstate Commerce Commission Regulations, must be printed or stamped on the shipping order in the lower left-hand corner and signed by shipper.

Under this certificate the offering for shipment of any forbidden explosives, cases of dynamite showing stains of any nature caused by leakage of any substance from within the case, explosives not packed in accord with Interstate Commerce Commission Regulations, or any explosives misnamed on the package or on the shipping order, is a violation of Section 235 of Act of Congress of March 4, 1909, and punishable by fine and imprisonment.

Always ship oldest stock first, but do not offer for shipment broken or leaky cases of dynamite or kegs of powder or stock which does not comply with Interstate Commerce Commission Regulations.

Empty boxes previously used for dynamite must not be again used for shipment of any character.

Empty dynamite boxes should be burned by piling a few of them in a pile, pouring a little oil over and igniting them by a little straw, shavings or paper, immediately going to a place of safety a few hundred feet distant and remaining until the boxes have burned.

Interstate Commerce Commission Regulations require railroad companies to furnish proper cars for shipping explosives and require that whoever loads the car must furnish the lumber and brace the shipments in accordance with methods prescribed by the Explosives Bureau.

Boxes of explosives must be loaded in the cars top side up, with their long dimension parallel to the length of the car.

Explosives in kegs, except where boxed, must be loaded on their sides with heads toward the ends of the car.

Explosives delivered to railroad station must be loaded, stayed and braced by railroad company.

A car of explosives must not contain more than 70,000 pounds gross weight.

### MAGAZINES

This Company has plans and specifications for standard storage magazines, which we will be glad to furnish on request. Ask for Pamphlet No. 1—Standard Storage Magazines.

When it is necessary to thaw explosives use only the methods recommended by manufacturers of explosives.



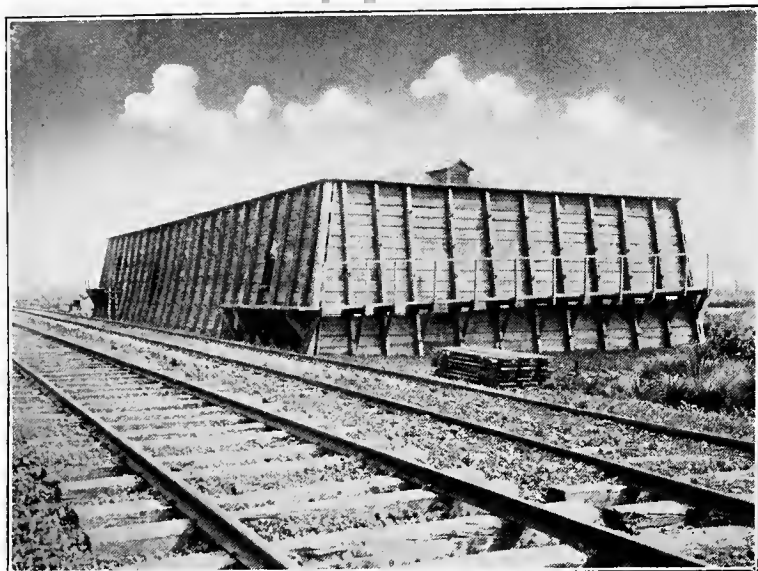
AN EXCELLENT SITE FOR A STORAGE MAGAZINE

**THE FOLLOWING SETS OF RULES ARE RECOMMENDED  
BY THE INSTITUTE OF MAKERS OF EXPLOSIVES  
TO BE CONSPICUOUSLY POSTED IN MAGA-  
ZINES CONTAINING EXPLOSIVES**

**RULES FOR DYNAMITE MAGAZINE**

**Recommended by Institute of Makers of Explosives**

1. Store only dynamite in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.
  2. Explosives should be handled carefully.
  3. Store dynamite boxes flat, top side up. Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked, and so that oldest stocks can be shipped, delivered or used first.
  4. Always ship, deliver or use oldest stocks first.
  5. Do not throw dynamite boxes violently down or slide them along the floor or over each other or handle them roughly in any manner.
  6. Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.
  7. Use a wooden wedge and mallet in opening or closing packages of dynamite.
  8. Do not use metal bale hooks in handling, or metal tools to open packages of explosives.
  9. Do not have loose dynamite or open dynamite boxes in this magazine.
  10. If artificial light is needed use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.
  11. Do not carry or allow others to carry matches or smoke in or near this magazine.
  12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.
  13. Keep this magazine clean.
  14. If leak develops in magazine roof or walls, repair it at once.
  15. Keep ground around magazine clear of leaves, grass, trash, stumps or debris to prevent fire reaching it.
  16. Do not allow unauthorized persons in or near magazine.
  17. Keep constant watch for broken, leaky or defective packages.
  18. Do not use empty dynamite cases.
  19. If any packages of dynamite are received in leaky or damaged condition, put packages to one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.
  20. Keep door of this magazine securely locked when not engaged in it.
- Note.—(It is suggested copy of above rules be posted in dynamite magazines for guidance of persons in charge of magazine.)  
(Fuse may be stored in same building with dynamite.)



A GOOD TYPE OF A LARGE HIGH EXPLOSIVE MAGAZINE



PORTABLE MAGAZINE ON A BRICK FOUNDATION

## RULES FOR POWDER MAGAZINE

Recommended by Institute of Makers of Explosives

1. Store only powder in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Store powder kegs on ends (bungs down) or on sides (seams down). Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be shipped, delivered or used first.

4. Always ship, deliver or use oldest stocks first.

5. Do not throw powder kegs violently down or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open kegs of powder or repack powder in a magazine or within 50 feet of a magazine.

7. Do not have loose powder on a magazine floor, in or around magazine.

8. Open powder kegs by removing the slide or unscrewing the (top) bung.

9. Do not use metal tools to open or close kegs of powder.

10. If artificial light is needed use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.

11. Do not carry or allow others to carry matches or smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps or debris to prevent fire reaching it.

16. Do not allow unauthorized persons in or near magazine.

17. Keep constant watch for broken, leaky or defective kegs.

18. Do not use empty powder kegs.

19. If any packages of powder are received in leaky or damaged condition, put them to one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.

20. Powder kegs should be thoroughly shaken by hand sufficiently often to prevent caking. Don't knock against floor or each other.

21. Keep door of this magazine securely locked when not engaged in it.

Note.—(It is suggested copy of above rules be posted in powder magazines for guidance of persons in charge of magazine.)

(Fuse may be stored in same building with powder.)

## MAGAZINE RULES FOR DYNAMITE AND POWDER MAGAZINE

### Recommended by Institute of Makers of Explosives

1. Store only dynamite and powder in this magazine. Do not store blasting caps or electric blasting caps, inflammables, metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Store dynamite boxes flat, top side up. Store powder kegs on ends (bungs down) or on sides (seams down). Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be shipped, delivered or used first.

4. Always ship, deliver or use oldest stocks first.

5. Do not throw packages of explosives violently down or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open packages of explosives or pack or repack explosives in a magazine or within 50 feet of a magazine.

7. Use a wooden wedge and mallet in opening or closing packages of explosives. Open powder kegs by removing the slide or unscrewing the top (bung).

8. Do not use metal bale hooks in handling, or metal tools to open packages of explosives.

9. Do not have loose dynamite or powder in this magazine.

10. If artificial light is needed use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.

11. Do not carry or allow others to carry matches or smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps or debris to prevent fire reaching it.

16. Do not allow unauthorized persons in or near this magazine.

17. Keep constant watch for broken, leaky or defective packages.

18. Do not use empty dynamite cases or powder kegs.

19. If any packages of dynamite or powder are received in leaky or damaged condition, put packages one side in magazine and make full report in detail to manufacturer, giving probable cause of damage.

20. Powder kegs should be thoroughly shaken by hand sufficiently often to prevent caking. Don't knock against floor or each other.

21. Keep door of this magazine securely locked when not engaged in it.

Note.—(It is suggested copy of above rules be posted in magazine used for storing dynamite and powder for guidance of persons in charge of magazine.) (Fuse may be stored in same building with dynamite and powder.)

## RULES FOR BLASTING SUPPLIES MAGAZINE

Recommended by Institute of Makers of Explosives

1. Store only blasting supplies in this magazine, *i. e.*, blasting caps, electric blasting caps, fuse, blasting machines, etc. Do not store dynamite or powder, inflammables, steel or metal tools or other implements in this magazine.

2. Explosives should be handled carefully.

3. Corresponding grades and brands should be stored together in such manner that brand and grade marks will show. All stocks should be stored so as to be easily counted and checked and so that oldest stocks can be shipped, delivered or used first.

4. Always ship, deliver or use oldest stocks first.

5. Do not throw boxes of blasting supplies violently down or slide them along the floor or over each other or handle them roughly in any manner.

6. Do not open packages of blasting caps, electric blasting caps or fuse until necessary to fill orders or use them, then close the package.

7. Use a wooden wedge and mallet, except where lids are screwed on use a screwdriver, for opening or closing boxes of blasting supplies. Do not keep any other metallic tools in this magazine.

8. Do not use metal bale hooks in handling, or metal tools to open packages of blasting supplies, except a screwdriver where lids are screwed on.

9. Do not have loose blasting caps, electric blasting caps or coils of fuse in the magazine or take them out of the original package until necessary to fill orders or use them.

10. If artificial light is needed use only an electric flash light or electric lantern. Do not use oil-burning or chemical lamps, lanterns or candles in or around this magazine.

11. Do not carry or allow others to carry matches or smoke in or near this magazine.

12. Do not allow shooting nor permit anyone to have firearms or cartridges in or near this magazine.

13. Keep this magazine clean.

14. If leak develops in magazine roof or walls, repair it at once.

15. Keep ground around magazine clear of leaves, grass, trash, stumps or debris to prevent fire reaching it.

16. Do not allow unauthorized persons in or near magazine.

17. Use extreme care in opening or closing packages of blasting supplies.

18. Keep door of this magazine securely locked when not engaged in it.

19. Do not store fuse in a hot place. Fuse should be kept cool and dry.

Note—(It is suggested copy of above rules be posted in blasting supply magazines for guidance of persons in charge of them.)

# PROPER METHODS FOR THAWING DYNAMITE

In all climates where the temperature falls below the freezing point of dynamite (45° F. or 7° C.) at some time during the year, the question of convenient and safe methods of thawing dynamite is of vital interest to anyone carrying on blasting operations during the winter months.

It is the purpose of this chapter to offer suggestions to our customers which will enable them to thaw dynamite safely and as economically as consistent with their individual needs.

Nitroglycerin explosives of practically all grades freeze at a temperature of from 45° to 50° F. or from 7° to 10° C. Low-freezing dynamites—Du Pont Gelatin, Repauno Gelatin, all kinds of Red Cross explosives, Du Pont RRP, F, FF and FFF and Du Pont Quarry Powder—resist cold much better than the other kinds. Even these low-freezing dynamites will become chilled by long exposure to extremely cold weather and thawing is still necessary. *When in a frozen condition dynamite can never be completely detonated, and often not at all*, and when partially detonated will give off poisonous fumes or burn up in the bore hole. It is therefore of extreme importance to *never use frozen dynamite*. Some provision must be made for thawing it and also for keeping it thawed until it is loaded into the bore holes.

There are various ways of thawing high explosives, but the only *safe* methods are those which *thaw slowly and gradually*. It is not at all necessary that the cartridges should feel warm; all that is necessary is to have them *soft all the way through*.

Details of various methods of thawing for varying quantities of dynamite are described in the following pages.

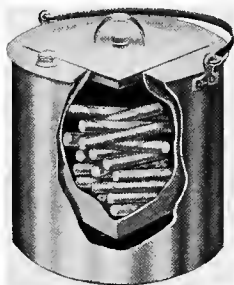
## THAWING KETTLES

For temporary use, where only a small amount of dynamite will be required, no improvement has yet been made over the thawing kettle. On work where large quantities of explosives are used, thawing houses will be found necessary, but even then, although the kettle may be too small for thawing purposes, it is still a great convenience for carrying explosives from the thawing house to the place where they are to be used, in order to prevent them from becoming chilled or frozen again. If not more than two or three

hundred pounds of dynamite is needed at a time, three or four large kettles are all that will be necessary to thaw this quantity thoroughly in a very few hours.

The Du Pont (Catasauqua type) of thawing kettle is made with water-tight compartment for the explosives, which is surrounded by the receptacle for the hot water. This kettle is made in one piece.

In using the Du Pont thawing kettle it is absolutely necessary to heat the water in some other receptacle and then fill the water compartment. Under no circumstances must the water be heated in the Du Pont kettle, because of the danger of firing some of the nitroglycerin left in it from the heating of the previous lots of dynamite. The hot water must always be tested before filling the dynamite compartment. If water is hot enough to burn the hand, don't put explosives into the kettle. Never fill the water jacket unless the explosive compartment is empty, and see that the explosive compartment is perfectly dry and clean before it is filled. Dynamite should never, under any circumstances, be permitted to come in contact with hot water.



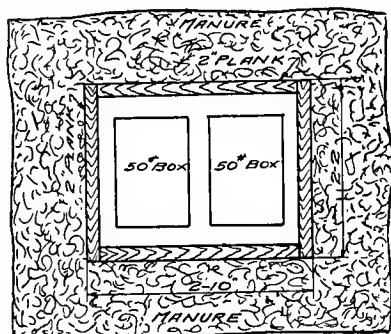
DU PONT THAWING KETTLE  
(CATASAUQUA TYPE)

The Catasauqua type of Du Pont Thawing Kettles will retain their heat about five times as long if the kettle is placed in a barrel filled with dry hay. A cylinder of wire screen can be made to hold the hay in place, so that the kettle itself may be removed and replaced without disturbing the hay packing. If the barrel is mounted on wheels, it can be moved from place to place about the work so that it will not be necessary to expose the dynamite to cold air until it is ready to be loaded in the bore holes.

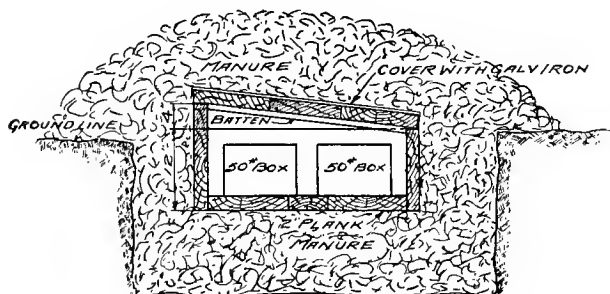
### Size and Capacities for Thawing Kettles

	Capacity In Pounds Of Dynamite	Weight Empty	Weight of Water	Total Weight Filled	Outside Dimensions
Du Pont No. 1	30	12½	40	82½	14" x 14½"
Du Pont No. 2	60	17½	77½	155	17½" x 21"

# DYNAMITE THAWING BOXES WITH MANURE FILLED WALLS



PLAN



SECTIONAL ELEVATION

NOTE! LIDS OF DYNAMITE BOXES TO BE TAKEN  
OFF WHEN PLACED IN THAWING HOUSE.

SINGLE THAWING BOX

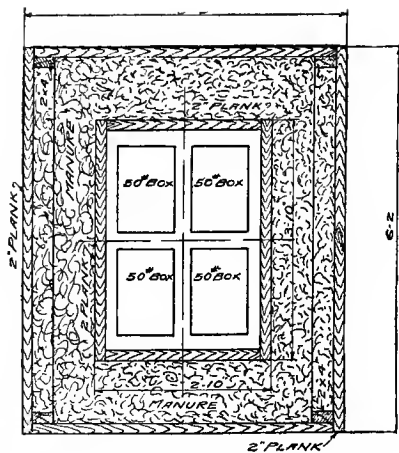
A simple and effective thawing arrangement may be made by suspending some receptacle filled with dynamite in a larger bucket partly filled with warm water. Care must be taken, however, to prevent the water from getting into the pail containing the dynamite, which should have a water-tight lid. The whole should be covered with a piece of carpet or old coat until the dynamite is thawed. When larger quantities of dynamite are required on temporary work, an excellent device is to place the cartridges in a large dry, water-tight milk can, the bottom of which is covered with sawdust, the can to be placed in a cask or barrel containing water which has been previously heated by a jet of steam, or if steam is not obtainable the cask may be filled with warm water as often as is necessary. If the water in the cask is to be heated by a jet of steam, the milk can containing the dynamite must always be taken out of the cask while the water is being heated. The water must always be tested before filling dynamite compartment. If the water is hot enough to burn the hand, don't put in the explosives. The cask should be covered with insulating material to retain the heat.

### THAWING BOXES

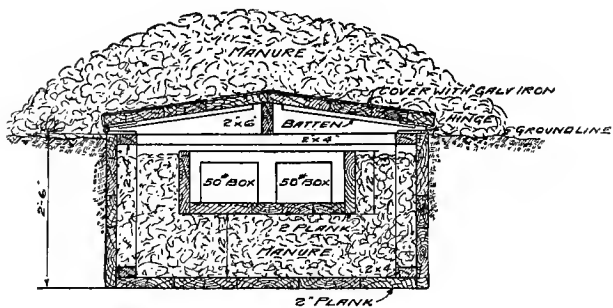
Stable manure is frequently used to thaw dynamite and is fairly satisfactory, provided always it is fresh. Under no circumstances, however, should the cartridges be allowed to come in actual contact with manure, since they might absorb moisture.

On page 38 is shown a manure-filled thawing box for one hundred pounds of dynamite in fifty-pound cases. A box is shown, made of 2-inch plank, with sloped lid, which may be covered with galvanized iron. This box is placed in a pit of sufficient size to receive it, and at the same time permit the packing of sufficient manure between the box and the earth, on sides and bottom and also on top when the box is in use. The size of the pit will depend on the amount of explosives to be thawed and the amount of manure it is necessary to use as packing. Since the depth which it may be necessary to make this packing varies with the nature of the climate as well as the frequency with which it may be convenient to renew the manure, it is impossible to give definite dimensions for this pit, but *remember* that the ordinary types of dynamite freeze at between 45° and 50° F., and the amount of protection necessary should be judged accordingly.

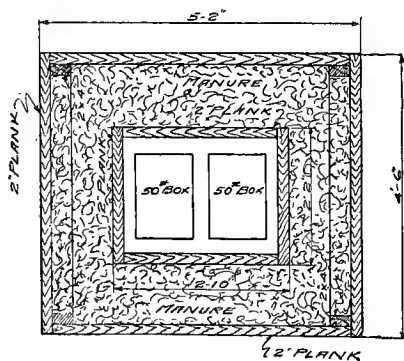
In the illustrations on page 38 the box is designed to hold one hundred pounds of dynamite in fifty-pound cases, but the



PLAN  
FOR  
FOUR 50° BOXES



SECTIONAL ELEVATION  
FOR  
TWO & FOUR 50° BOXES



PLAN  
FOR  
TWO 50° BOXES  
DOUBLE THAWING BOX

dimensions may be increased to hold much larger quantities. Be sure, however, in planning the box to have sufficient space (about 2 inches) between cases to permit a uniform thawing and also convenient handling, and also to have sufficient manure packing to insure complete thawing.

The illustrations on page 40 show a slightly more elaborate arrangement of two boxes, to be used where the nature of the soil makes the outer box advisable or necessary. In this case the pit is dug so as to just receive the outer box, space being left inside for lining with manure, and smaller box put in to hold the dynamite.

The thawing boxes shown in the figure are designed for two and four cases, but may be built to take larger quantities, always, however, being sure that space is left between the cases.

Tops of cases should be removed before placing dynamite in the thawing boxes.

Assuming an average cost of labor and materials, these boxes will cost about as follows:

For two 50-pound cases, single box.....	\$ 3.00
For two 50-pound cases, double box.....	11.00
For four 50-pound cases, double box.....	16.00

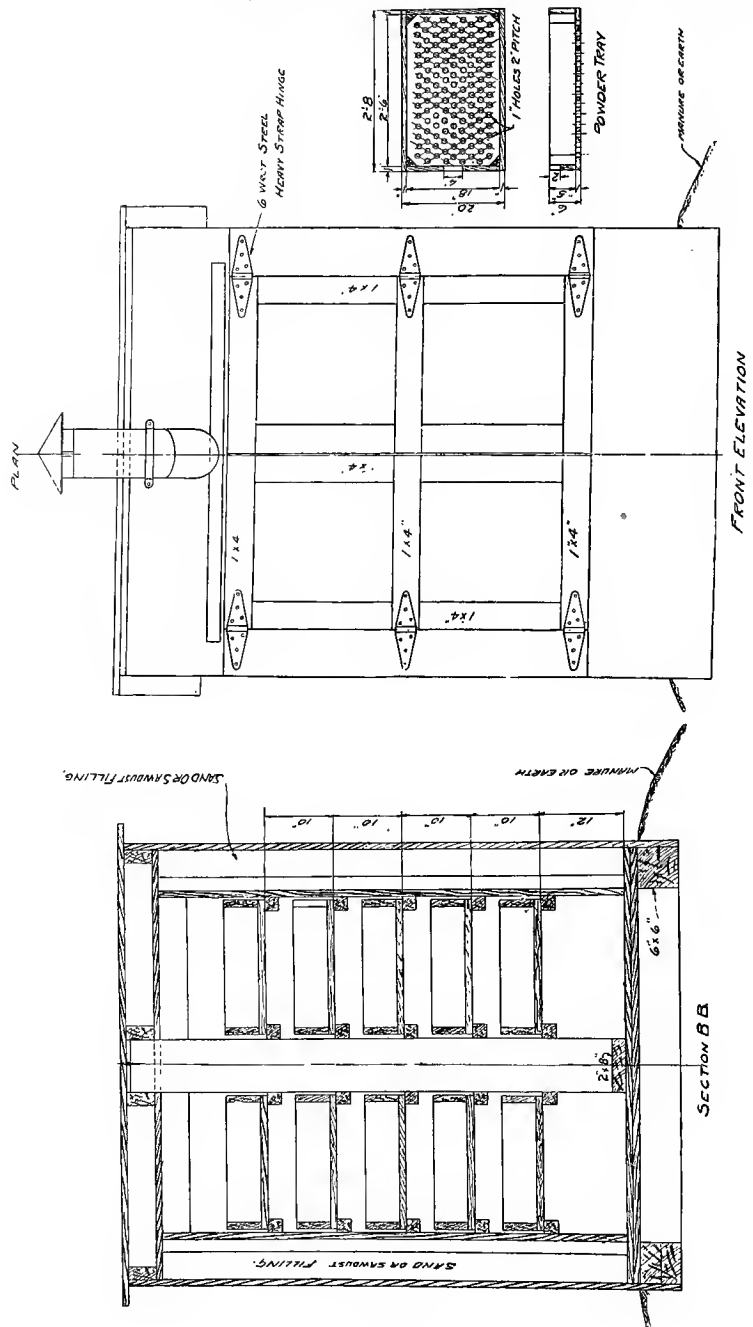
These figures include excavation for the pit, manure packing, and new material throughout. It can easily be seen that these figures are but an approximation, for the cost of labor and material will vary greatly in different parts of the country. It will also occur to a number of persons wishing to use these thawing boxes, that they can utilize old "scrap" lumber, that their own stables will supply plenty of fresh manure, and that they themselves can put the boxes together. This would place the correct cost to the majority of individuals for any one of the above thawing boxes much lower than the above figures. It is intended that these figures act merely as a guide from which each person may base his individual estimate.

## DYNAMITE THAWING HOUSE

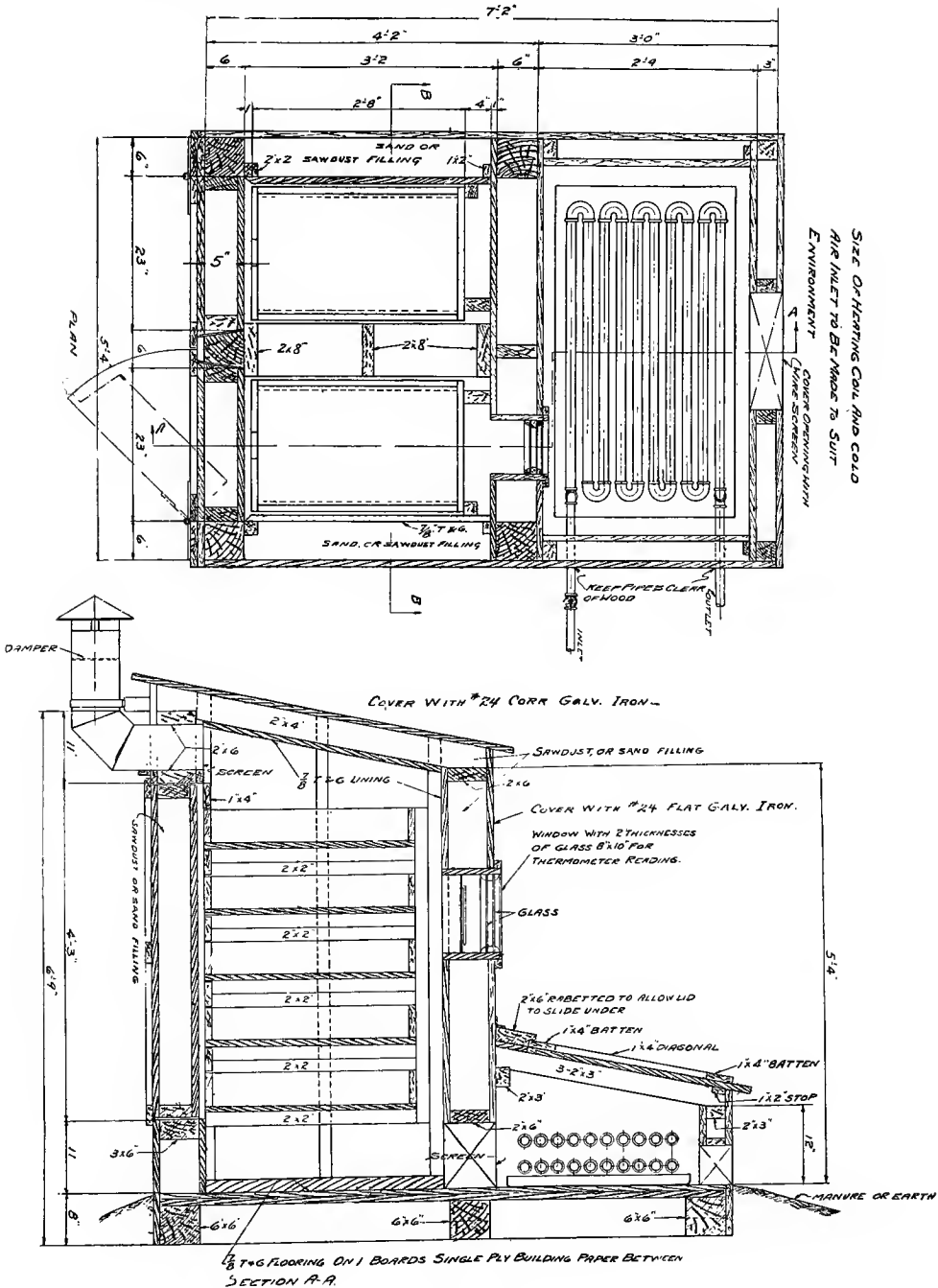
### Heated Only by Exhaust Steam

The illustrations on pages 42 and 43 show a type of permanent thawing house *to be heated only with exhaust steam*. Exhaust steam is usually the most convenient and economical heat which can be used, for on the majority of permanent work where explosives are used, there is an engine or pump, the exhaust steam

# Dynamite Thawing House



# Heated Only by Exhaust Steam



from which may be utilized at nominal cost for supplying heat in thawing house. It is dangerous to use live steam or steam under pressure, on account of the possibility of high temperatures. This house is designed to thaw 500 pounds of dynamite at a time in trays holding fifty pounds each. If it is desired to have larger capacity, increase the thawing house in units of 250 pounds each (or half the original house) and also increase the radiating surface of the steam coil to suit. This increase in capacity can be carried out to any extent desired. The amount of radiating surface necessary will vary with the climatic conditions, care being taken, however, to provide sufficient heat to insure complete thawing. In installing the steam coil, be sure to give the pipes sufficient slope to drain properly. If it is preferred, the same type of coil may be installed in this thawing house as in the one designed for hot water heating, shown on pages 46, 47 and 48.

The packing in the walls of this house is specified as either sand or sawdust. Dry sand is a very good insulating material, but would make ship-lap or tongue and grooved boards necessary on the outside walls to hold it in place. Never use *coarse gravel* for packing, on account of missiles which would be thrown in case of an accidental explosion of the thawing house. Dry sawdust is probably the best economic packing to be chosen. Of course, mineral wool or asbestos fibre would give a more perfect insulation, besides being fire-proof, but in some cases the cost would be prohibitive.

A thermometer is placed in the back wall of the thawing house behind a double glass window so that the temperature in the house may be determined without opening the doors and admitting cold air. A damper is also placed in the stack to permit the regulating of the circulation of the air through the house.

90° F. or 32.2° C. is a good thawing temperature.

If it is desired, a small box on wheels or a cart can be made of a size to just receive a certain number of the trays from the thawing house. Whatever number of trays are needed at a time may be placed in the cart, covered and taken to the work without exposing the dynamite to the cold air until it is ready for loading in the bore holes.

The thawing house should always be kept locked, and only one person allowed access to it. Use a good grade of standard make padlock.

This house can be built of new materials at an approximate cost of \$100. In this house, as in those previously mentioned,

the judgment of the individual may be applied in selecting materials to be used. Almost every piece of permanent work will have enough pipe lying around to make up the heating coil and "scrap" lumber to help out in the construction. Such planning will cut down very materially the cost of installing such a thawing house.

It will be noted that there is no space in this house to permit a person to enter, so that it is impossible to use this house as a place to prime cartridges. Several disastrous accidents have been caused by priming dynamite in the thawing house.

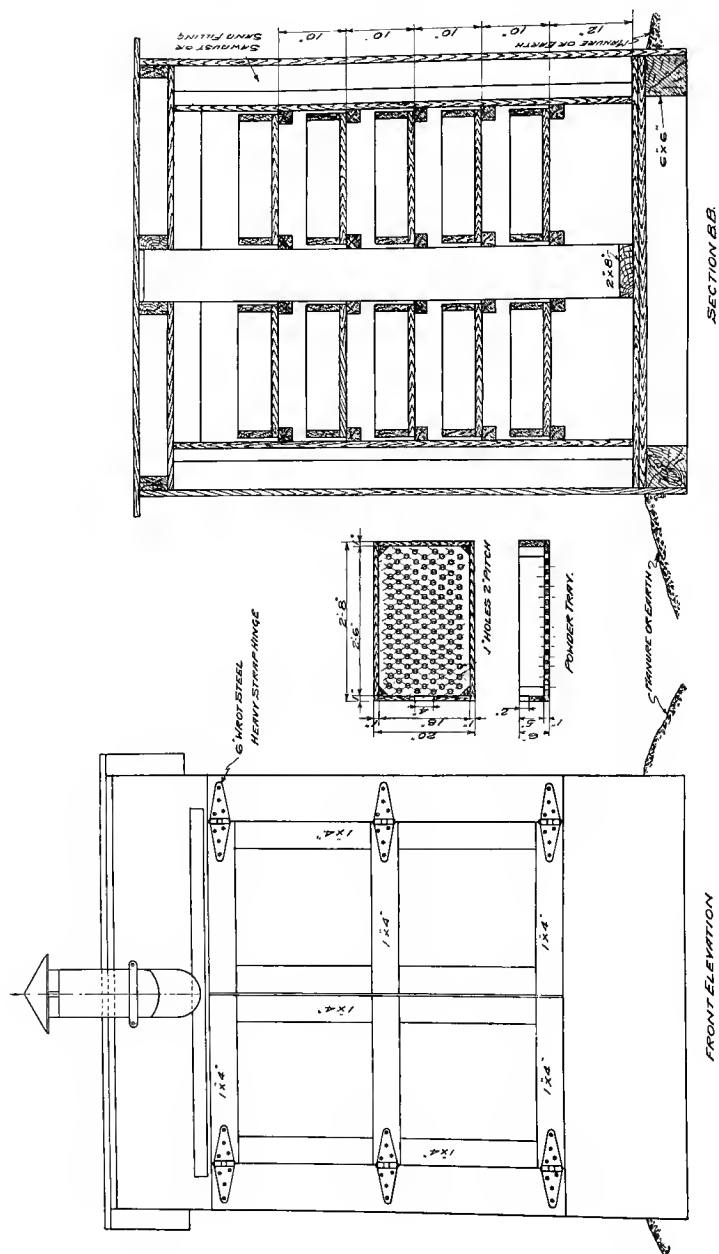
## DYNAMITE THAWING HOUSE

### Heated by Hot Water

On pages 46, 47 and 48 is shown a permanent thawing house to be heated with hot water. This house is designed to thaw 500 pounds of dynamite at a time, in trays of fifty pounds each. If greater capacity is desired, increase the size of the house in units of 250 pounds, increasing the radiating surface of the coils and the size of the heater accordingly. All details of construction in regard to the thawing house itself which were taken up in the discussion of the thawing house heated by exhaust steam, will apply in this case. The illustration also shows a heater house and a standard type of heating unit for small hot water systems. In installing this system, it is imperative that the heater house is enough lower than the thawing house to permit a good gravity flow in the return pipe from the heating coil in the thawing house to the heater. The heater house should be built at a distance of from 30 to 50 feet from the thawing house. Added distance increases the cost of construction, and diminishes economy of operation, while too close proximity to the thawing house adds to the fire risk. The pipes between the buildings which are exposed to the open air should be covered with standard magnesia pipe covering, or placed in a sawdust filled box.

This house can be built of new materials at an approximate cost of \$175. In this house, as in the case of those mentioned previously, the judgment of the individual may be applied in selecting materials to be used, and the use of old materials on hand will cut down the cost.

## Dynamite Thawing House



The technical drawing illustrates the construction of a cold room, divided into two main sections: a plan view on the left and an elevation view on the right.

**Plan View (Left):**

- Overall Dimensions:** The total width is 7' 8" (comprising 4' 2", 3' 0", and 6"). The total depth is 23' 0" (comprising 23', 6", and 4").
- Internal Layout:** The interior features a large central rectangular space. To its right is a narrower section containing a "COLD COIL". Below the main space is another rectangular area labeled "SAND OR SAWDUST FILLING".
- Labels:** "PLAN" is written vertically on the far left. "SAND OR SAWDUST FILLING" appears twice, once near the top and bottom center.

**Elevation View (Right):**

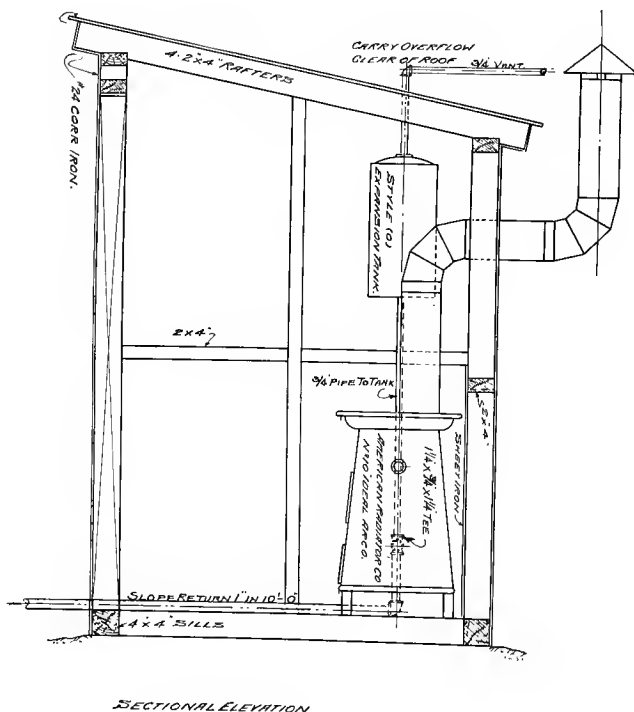
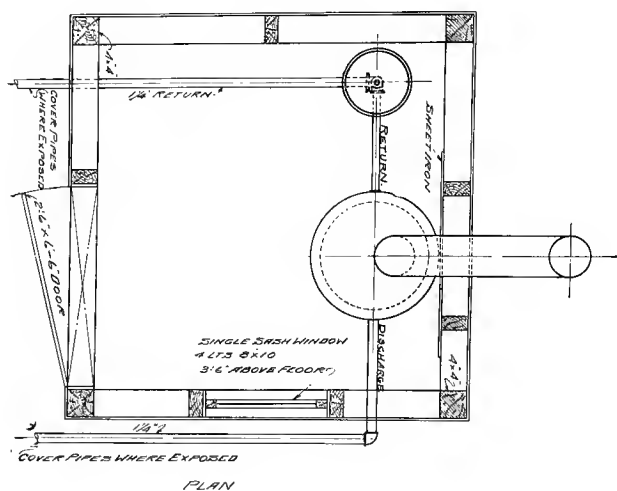
- Cold Coil:** A vertical assembly of horizontal pipes or tubes, labeled "COLD COIL".
- Dimensions:** The height of the coil section is 12' 0". The distance between the coil and the outer wall is 4".
- Labels:** "COIL OPENING IN WALL HEREIN" points to the base of the coil. "SIZE OF COIL & COLD AIR INLET TO BE DETERMINED BY ENVIRONMENT" is written vertically along the right side.

**General Notes:**

- "CONCRETE FLOOR" is indicated at the very bottom of the diagram.
- "WOODEN WIRE SCREEN" is noted near the bottom right corner.



# Dynamite Thawing House Heated by Hot Water



## THAWING HOUSE HEATED BY EXHAUST STEAM OR HOT WATER

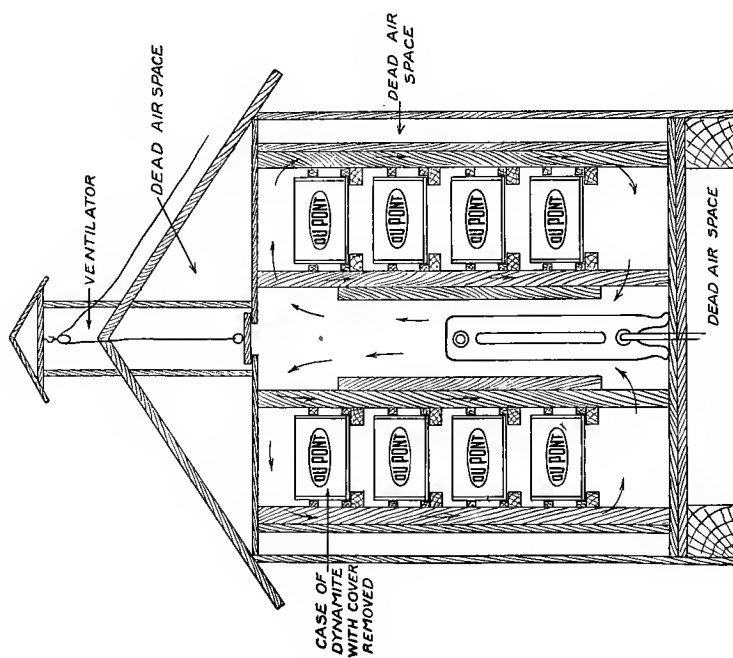
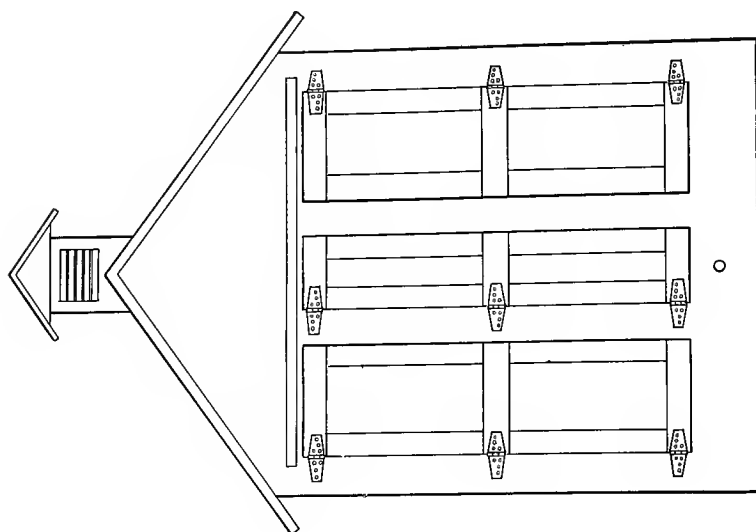
The illustrations on pages 50 and 51 show a type of permanent thawing house to be heated with exhaust steam or hot water, having a capacity of 5,000 pounds of dynamite each. This house is designed to thaw the dynamite in the original cases in which it is received.

There are three compartments, divided by vertical partitions extending almost to the floor and the ceiling. In the central compartment is the radiator coil or pipe, which is heated by exhaust steam or hot water. On either side of this central compartment the dynamite boxes are placed in horizontal racks so constructed that no nails, screws or bolts project from the runways. Four racks are built on each side of the heating compartment into each of which five dynamite boxes can be slid from one end of the house to the other. Doors giving access to the dynamite compartments are constructed at both ends, and a door giving access to the heating compartment is constructed at one or both ends.

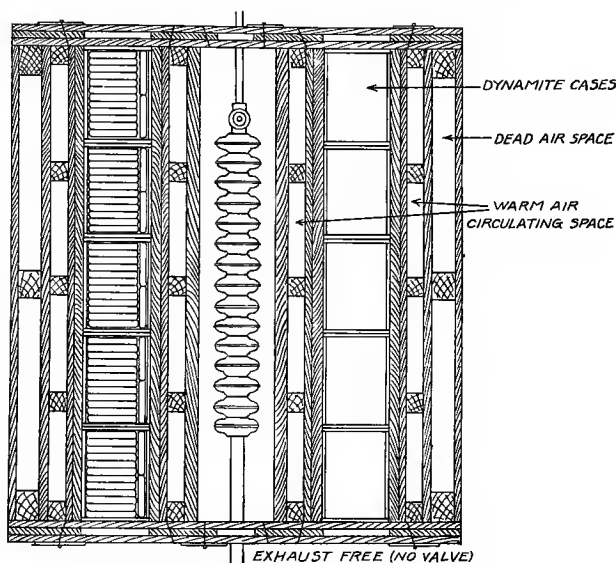
In operation, the key to the door of the heating compartment is in the hands of the person in charge of the heating arrangements, not the quarry foreman nor magazine-keeper. The keys to the doors at one end of the dynamite compartments are given into the hands of the magazine-keeper, who, from time to time slides fresh dynamite cases into the racks, so as to fill the compartments. The foreman of the quarry has the keys to the doors at the opposite end of the thawing house, from which he removes the dynamite cases nearest the end which have been longest in the thawing house, and which should be thoroughly thawed.

The thermometer should be placed in the dynamite compartments in such a way that it can be read without entering the house, and a device should be provided for regulating the temperature of the dynamite compartments. In such a thawing house, or several of them, dynamite may be thawed in such quantities as are required in modern practice, such as loading well-drill holes, etc. There is no place where a workman would be tempted to make up primers, and no chance of the dynamite being placed directly over the heater. This type of thawing house has proven quite successful in a number of large operations.

# Dynamite Thawing House Heated



## by Exhaust Steam or Hot Water



## USING HIGH EXPLOSIVES

### SELECTION OF THE DETONATOR

In detonating high explosives the stronger or “sharper” the initial shock the quicker and more thorough is the detonation of the charge. It is a well-known fact that certain detonating substances will exert this effect more powerfully than others. To obtain the full value of the explosive charge it should be detonated as quickly and completely as possible. If the detonation is slow and incomplete a greater quantity of explosive is required to do the same work, and large volumes of poisonous gases are evolved,—a matter of serious consequence when the work is underground, instances being known where workmen have been killed by gases given off by partially detonated or burning explosives. Quick and complete detonation also results in a minimum of flame—a point of first importance with those explosives intended for use in the presence of inflammable gas or coal dust.

Electric blasting caps or blasting caps too weak to detonate a charge of high explosives frequently generate sufficient heat to ignite it, while slightly stronger ones may partially detonate it, or perhaps

bring about complete detonation, but with insufficient rapidity to give best results. The effect of a detonator on a charge of high explosives in a bore hole is not infinite, but decreases with distance. It is therefore easy to understand the necessity for using detonators sufficiently strong for the effect of the detonator itself to extend throughout the charge. It might be understood from this that the detonator should be located in the center of the charge, and this would be correct, had not numerous tests shown that the greatest effect of the detonator is straight away from its loaded end in a line with its long axis. That is, a detonator will explode a cartridge of dynamite farther away from it if it is lying with the loaded end pointed toward the cartridge than it will if it is lying parallel to or away from the cartridge. In deep bore holes loaded with long charges, it is well to place several electric blasting caps at intervals throughout the charge so that the effect of the detonating compound which they contain will extend the entire length of the charge. This will reduce the chances of a misfire due to a defective electric blasting cap. These should be connected in series and not in parallel if the source of the electric current is a blasting machine.

A point to be remembered in buying detonators is that the charge which they contain is readily affected by moisture; and consequently, unless storage conditions are of the best, a fair margin of safety in strength should be allowed. Blasting caps, being open at one end, are more quickly weakened by dampness than are electric blasting caps.

Another strong argument for allowing a fair margin of safety when buying detonators is the very small cost of the detonator in comparison with that of the charge of explosives with which it is used. It is difficult to understand why any one, in order to save a few cents on the price of a hundred detonators, would risk the misfire, partial detonation or imperfect work of the charge of explosives in a bore hole, which results at best in the loss of several dollars, and may cost thousands if it burns in a gaseous coal mine, or if unexploded dynamite should happen to cause a fatal accident afterward.

## **BETTER EXECUTION WITH No. 8 BLASTING CAPS**

It has been a well-proven fact for some time that No. 6 detonators will get more work out of high explosives, particularly Gelatin and Extra grades, than the No. 5 and smaller sizes. It has also been proven that in large charges, such as those in well-drill

holes, four No. 6 detonators distributed at equal distances through the charge will give better execution than two detonators of the same size, and that two will do much better work than one. It has lately come to our notice that better execution can be had with Du Pont Gelatin with a No. 8 blasting cap than with a No. 6, and this in work where it is not possible to put more than one detonator in each charge.

In the western part of the United States, the superintendent of a gold-mining company, engaged in driving a tunnel for developing the property, had been using Du Pont 40 per cent. Gelatin with No. 6 blasting caps. Considering the possibility of better fumes, and possibly more complete detonation, he tried using No. 8 Du Pont Blasting Caps with the same gelatin and found to his surprise and delight that the progress per shift was increased from four to five inches. This increased progress is worth much more than increased price of the larger size blasting caps, and in many tunneling operations the increased distance per round of shots can be had in no other way than by increasing the size of the detonator. The number of drill holes which can be made is limited on account of the time and number of men and machines that can be employed at one time. It is not possible to increase the charges of explosive and it is often not possible to use an explosive of higher grade on account of the possibility of its being unsuited to the rock. It is not possible to increase the amount of explosive in each drill hole, as that would necessitate less tamping, which in turn would surely mean blown-out shots. It is probably not possible to develop the entire potential strength of any high explosive; the decomposition, theoretically at least, is always incomplete, but the more nearly the decomposition approaches completeness, the more work is done and the less noxious the character of the fumes. Practically complete decomposition of an explosive, with the production of its maximum disruptive power, can only be had by the greatest possible confinement; *i. e.*, tamping, and by the largest and strongest practical detonator.

Several years ago, during the driving of that portion of the New York subway which ran several hundred feet underground, from One Hundred and Eighty-eighth Street to Fort George, the contractors were straining every nerve to hasten the progress of their work, employing the most expert drillers and blasters, and though working under difficulties and through an exceedingly hard gneiss, were establishing a record at that time for progress in hard rock tunneling. During the progress of the work trouble was encoun-

tered at one of the headings from misfires. They were using a 60 per cent. gelatin and what are now known as No. 6 electric blasting caps. In an effort to eliminate the misfires a supply of much stronger electric blasting caps was substituted and their use continued for about two weeks. Engineers who were measuring the progress made day by day noticed an increased rate of from six to nine inches during the two weeks that the No. 8 electric blasting caps were used, although the other conditions, as grade of gelatin, number and position of drill holes, amount of explosive per drill hole, tamping, etc., remained the same. The engineer in charge immediately ordered a supply of the No. 8 electric blasting caps and when told that they would be somewhat more expensive than the No. 6 replied that they would be cheaper for him even if they cost \$20 per hundred more than the others, as he was obtaining much more than that value in progress gained in the tunnel.

Where blasting operations are of such a character that the drill holes are overloaded, that is, more explosive put in or stronger explosive than is actually necessary to break the rock, it is unlikely that the substitution of stronger detonators will be noticed; but where overloading the drill holes produces less effect, as in tunneling, where a definite amount of tamping is absolutely required to prevent the charges from blowing out, where the rock is hard and tough, and where accurate measurements are possible, it will be found in practically every instance that where a No. 8 detonator is substituted for the No. 6 better execution and better progress results.

## **UNITED STATES BUREAU OF MINES ON STRONG DETONATORS**

The extended study and tests of explosives conducted by the United States Bureau of Mines have clearly demonstrated the economy of using only strong detonators and we find on page 12, Miner's Circular No. 7, printed in 1914 by the Department of the Interior, Bureau of Mines, the following:

"The cost of detonators in comparison with that of the explosives, and the cost of drilling and preparation of the drill hole, is so small that it seems foolish to buy weak detonators simply because they are a little cheaper than strong detonators. Moreover, weak and unsuitable detonators cause high explosives to give off dangerous gases. All permissible explosives lose strength and sensitiveness

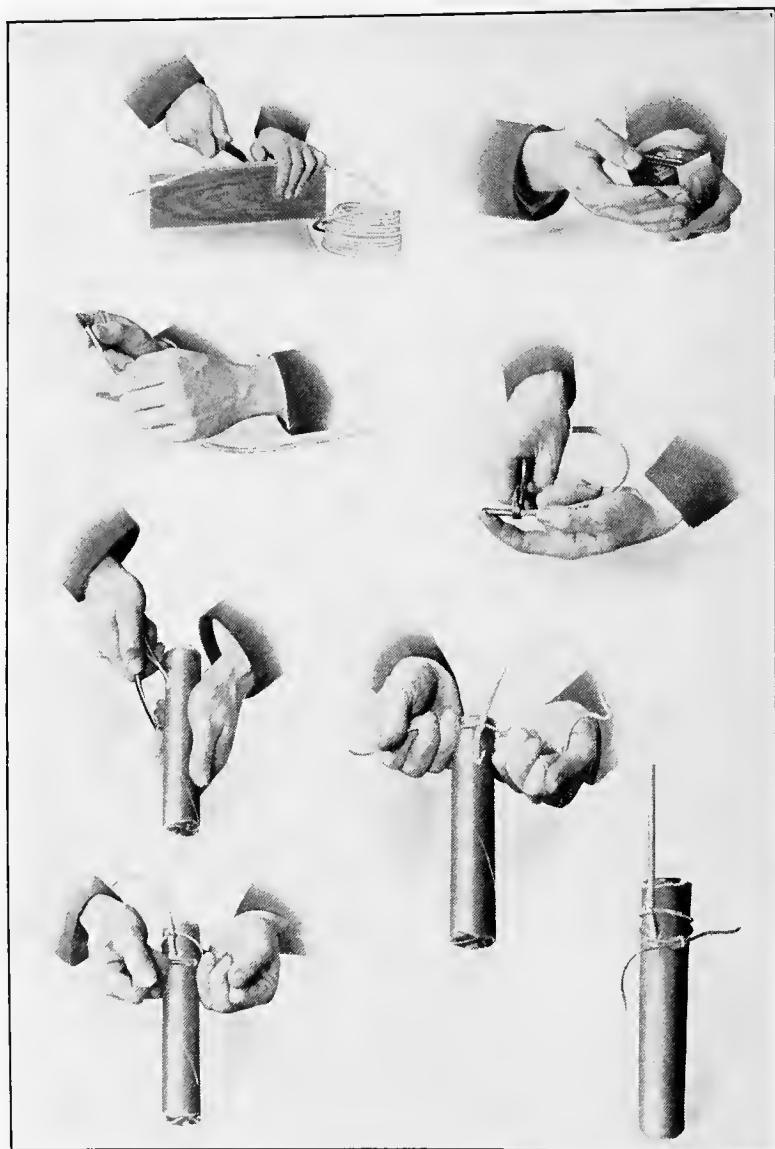
with age and improper handling, yet by the use of strong detonators, they may be made to explode completely.

"When high explosives are detonated, the stronger and quicker the action of the detonator, the greater will be the shock given the explosive and the more effective will be the explosion. In order to make sure that the charge will exert its greatest force, it should be properly tamped and should be detonated quickly and completely. If the explosion of the detonator is slow or incomplete, more of the explosives will be needed to do the work and larger quantities of poisonous gases will be given out. When the detonation is quickest and most complete, the least flame is produced. A detonator too weak to explode the explosive may produce the most heat and set fire to it and the burning explosives may give out poisonous gases. A weak detonator may be strong enough to cause the explosive to explode and yet not cause an effective explosion. Therefore the detonators used must be strong enough to detonate the charge completely."

## **WHAT THE UNITED STATES BUREAU OF MINES SAYS ABOUT ELECTRICAL BLASTING**

On page 14 of the same circular is found the following:

"Electricity is safer, quicker, more efficient, more certain and cheaper than any other means of setting off blasts. Often adjacent shots in the same working face yield the best results in the quantity and quality of the coal produced when they are fired at the same time. This is possible when the shots are fired electrically. For example: In a certain mine using permissible explosives, the yield of lump coal was increased 20 per cent. when the rib holes were all fired by electricity at the same instant. Wet holes can be fired more easily by electricity than by any other method. When electric firing is used the shots can be exploded while the person who is firing the shots is at a safe distance. The explosion follows immediately after the lever or switch has been thrown. There is no waiting as there is in firing with a fuse or squib, and misfires and hang-fires are rare. When fine coal dust is present in a bituminous mine or explosive gas in any mine, electric firing only should be employed, because squibs and fuse yield sparks and flames that can ignite gas or dust and cause explosion as of course they must be ignited in the open air by open flame."



PRIMING WITH BLASTING CAP AND FUSE (FIRST METHOD)

## **STRONG ELECTRIC BLASTING CAPS AND BLASTING CAPS SHOULD BE USED WITH ALL HIGH EXPLOSIVES**

Because they insure complete detonation.

Because they increase the execution of the explosive.

Because they tend to counterbalance careless and improper usage.

Because they offset, to some extent, deterioration due to improper storage.

Because they reduce the fumes to a minimum.

Because they decrease the size and duration of flame.

Because they prevent the loss of the charge by burning.

Because their effect carries farther in long charges.

Because they reduce the chances of misfire.

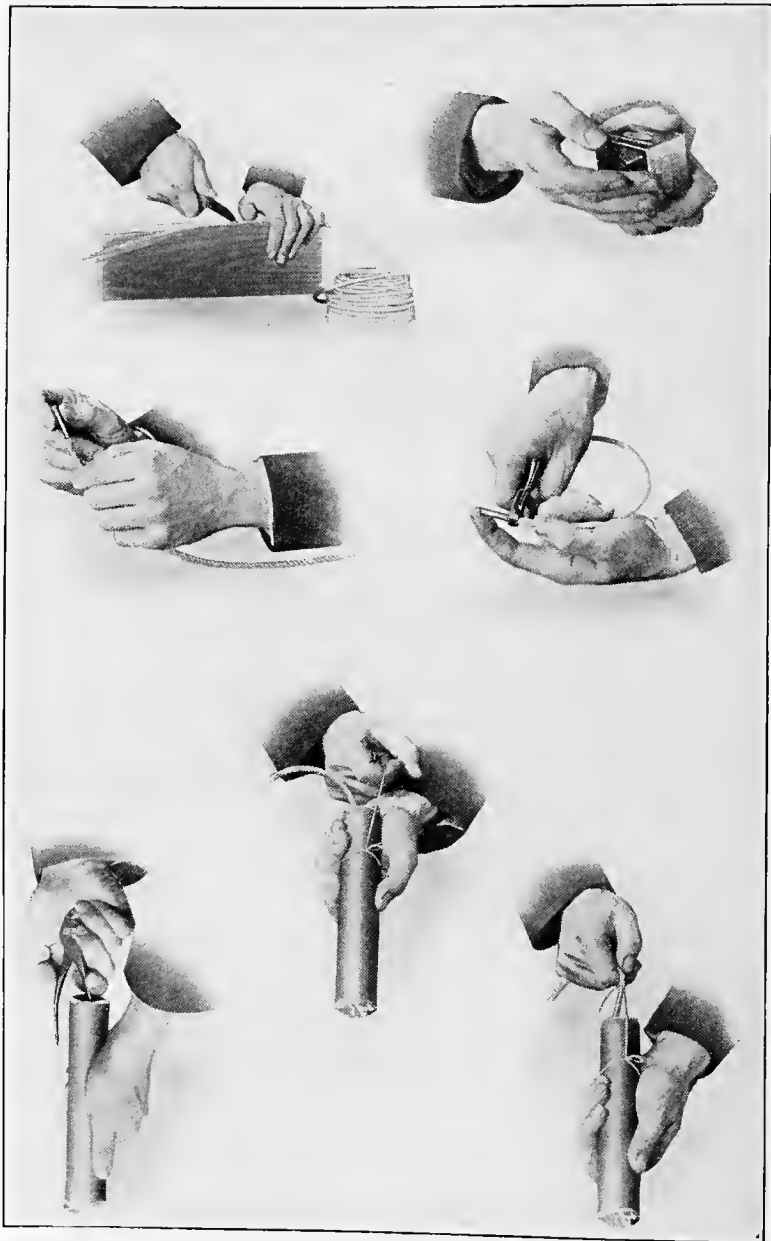
### **PRIMING**

A common cause of misfires in the use of explosives is lack of careful attention to priming. When using fuse and blasting caps, never lace the fuse through the cartridges of explosives, or bury the blasting cap so deep that the fuse will be in contact with the explosives for any considerable distance, for even the best fuse may spit fire laterally and ignite the explosive before the blasting cap is detonated. Burning explosives give off highly poisonous gases, and every precaution should be taken to prevent ignition of the charge. Careful observance of the following instructions will reduce priming troubles to a minimum:

## **TO PRIME A DYNAMITE CARTRIDGE WITH BLASTING CAP AND FUSE**

### **FIRST METHOD**

Cut off and discard an inch or two of fuse from the end of the coil. (It may have attracted moisture from the air). Use a sharp knife on a wooden block; or, if the amount of work warrants, a pair of good pruning shears makes an excellent fuse cutter. Cut fuse off square, not at an angle. Remove lid from box of blasting caps, tilt box with one hand to one side to extract a blasting cap. Insert end of fuse into blasting cap gently until it touches the charge in blasting cap. Do not twist the fuse as the friction might cause a premature explosion. Crimp blasting cap firmly on fuse with Du Pont cap crimper, crimping close to edge of copper shell.



PRIMING WITH BLASTING CAP AND FUSE (SECOND METHOD)

Take dynamite cartridge and punch slanting hole in side, about two inches from one end and directing point of punch toward other end of cartridge. Insert blasting cap crimped on fuse into this hole so that not more than a quarter inch of fuse is inside the cartridge shells. Tie a piece of string long enough to go twice around cartridge firmly to fuse about two inches from blasting cap. Bring the two ends twice around cartridge, tying the ends near point of insertion. See page 56.

If the work is wet, cover the safety fuse where it enters the blasting cap with soap or tallow to prevent water getting in to the blasting cap. *Oil or thin grease should never be used for this purpose*, as they may penetrate the safety fuse, and destroy the efficiency of the powder in it.

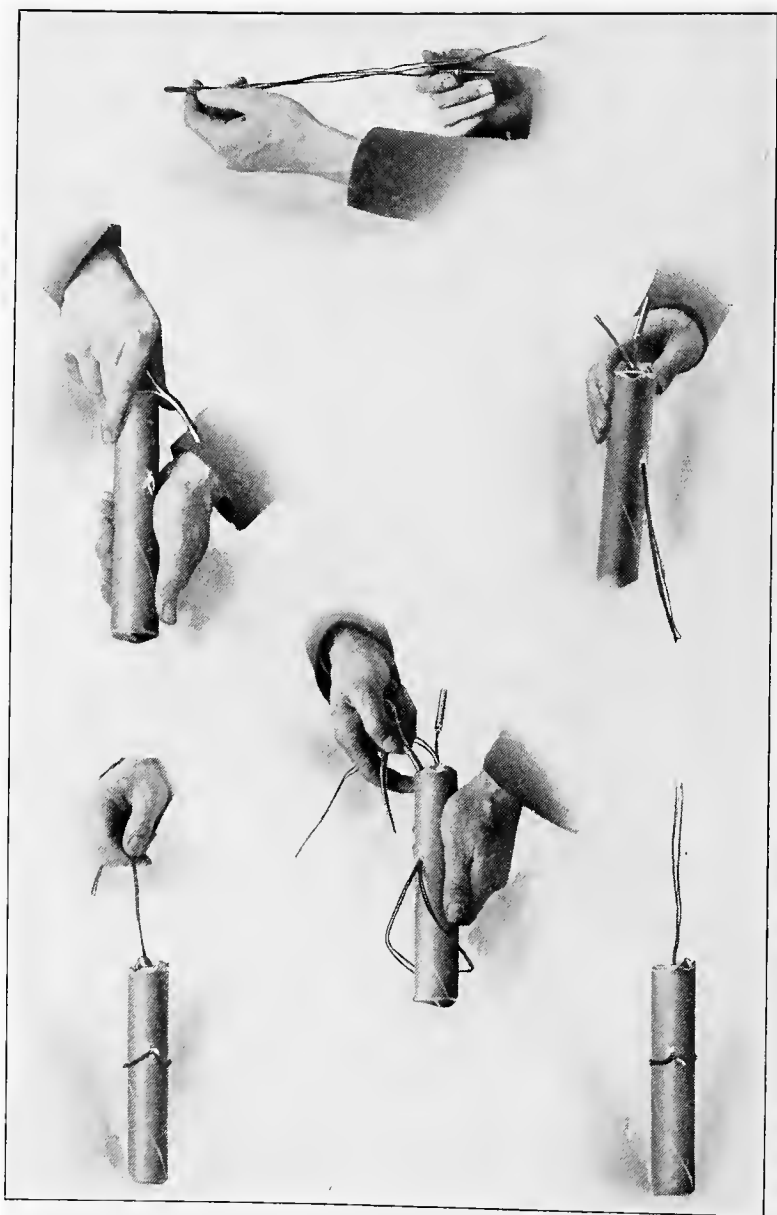
#### SECOND METHOD

Crimp blasting cap to fuse as before. Punch hole in end of dynamite cartridge. Insert blasting cap. Tie one end of a piece of string around dynamite cartridge about two inches from the end, firmly, so that it will not slip. Tie other end of string to the fuse about an inch above the dynamite cartridge. The strain of the fuse will now come on the string which, if tied tightly at both ends, will not allow the blasting cap to pull out. See page 58.

#### PRIMING WITH ELECTRIC BLASTING CAP

Either of the above methods may be used for priming with electric blasting caps, making sure that the string is tied to the wires so that it will not slip.

Another method of priming with an electric blasting cap, but which is not applicable with blasting cap and fuse, is to punch one hole diagonally from middle of the end of the cartridge coming out at the side two or three inches down. Straighten out the electric blasting cap wires and then double them, or bend them back about a foot from the capsule, and pass this doubled-up wire through the hole at the top and out at the side of the cartridge. Open the loop of the wire passed through and loop it over the lower end of the cartridge and bring it up around the cartridge. Punch another hole in the end of the cartridge a half inch away from the first hole and straight down. Insert the capsule of the electric blasting cap in this and take up all slack wire. The cartridge will now hang plumb from the wire, the wires will not cross each other, and the detonator is imbedded in the dynamite and pointing down. See page 60.



PRIMING WITH ELECTRIC BLASTING CAP

## AVOID THIS METHOD OF PRIMING

The common custom of taking one or more loops, or half hitches, around the cartridge with the wires themselves, after inserting the electric blasting cap in a hole made diagonally in the side of the cartridge near one end is always to be condemned. The principal objection is that the looping of the wires is very likely to break the insulation, causing short circuits, or leakage of current. Sometimes the wires themselves are broken, or the detonator separated from the cartridge.



FIRST POSITION

SECOND POSITION  
Due to Hard Pull on the Wire

Again, when an electric blasting cap from  $1\frac{1}{4}$  inches to 2 inches long is pushed into the side of a cartridge 1 inch,  $1\frac{1}{4}$  inches, or even  $1\frac{1}{2}$  inches in diameter, it very often occurs that the end of the cap where the principal part of the detonating charge is located goes entirely through the explosive itself even though it may not penetrate the paper shell. As it is often the custom when priming in this way to point the electric blasting cap diagonally toward the end of the cartridge, which will be nearest the outside or top of the charge, it can be readily seen that any pull on the wires hard enough to affect the position of the cap will tend to bring it more to a right angle with the long axis of the cartridge, and force its end still farther out of the opposite side of the cartridge, as shown in the two illustrations on this page. While this does not always cause

a failure it is quite possible that many lost shots may be attributed to it, especially when cartridges of small diameters are used.

### **PRIMING CARTRIDGES BEFORE NECESSARY**

The practice of making up a supply of primers long before they are to be used is one that should be discouraged by every mine superintendent or foreman. In spare time miners will sometimes make up many more than are needed and keep them several hours or days. While it is often convenient to have the primers made up before beginning loading, it is not as safe as making them at the time, and there have been a number of misfires reported from keeping the primers too long. The cause of these misfires is not fully known, but it is probably due to the nitroglycerin, which is an oil, soaking into the fuse, dissolving and thinning part of the asphalt waterproofing, making it run into the powder core so that the fire will go out when it comes to that place.

All rules and regulations for storing and transporting explosives expressly forbid storing or shipping dynamite and caps together on account of the danger of the sensitive and easily exploded caps setting off the dynamite. Yet primers are simply dynamite and caps put together, exactly the most dangerous combination that there is, and the storing and carrying them around together is often tolerated when they never would be allowed to be stored in different parts of the same magazine.

When dynamite by itself is set on fire it generally burns up without exploding, but when cartridges with caps inserted in them get on fire, an explosion invariably results.

Dynamite is sometimes ignited by sparks from miners' lamps, and when no caps are around may do no harm, except to drive everyone out from the effects of the noxious and poisonous fumes, but when the dynamite is primed it can burn at best only a few seconds and then it explodes; there is no uncertainty about that.

So many accidents have occurred where men have been killed, due to the presence of primed cartridges, and there have been so many narrow escapes from primers exploding, that there is no excuse for taking a chance of this kind.

### **TWO OR MORE ELECTRIC BLASTING CAPS IN A BORE HOLE**

The blasters who never have misfires are the blasters who place at least two electric blasting caps in each charge of explosives. A

missed hole is not only a nuisance and embarrassment, but it wastes time and is a source of danger as long as it remains. Some time ago, one of the leading technical papers invited discussion among its readers on the proper procedure in the case of misfires and it was noticeable that there were very few replies. This is not because misfires are so uncommon that miners and engineers have had no experience with them, but because most blasters are reluctant to admit, especially on paper, what they frequently do with holes which have missed fire. The directions of the explosive manufacturers, the Bureau of Mines and various authorities on the subject of blasting recommend or direct that the bore hole be left undisturbed and that a new hole be bored far enough away from the missed one to be perfectly safe, but near enough to it, so that when charged and fired, it will explode the charge in the old one. This looks easy enough on paper, but how about the bore hole that takes four or five days to drill, and the bore hole which has been sprung and contains several cases of explosives, the exact position of which is unknown? It is a regrettable fact that a large proportion of men using high explosives, when they encounter a charge which has misfired, forget their directions and take a chance on digging out the tamping, even though they know they are taking their lives in their hands in doing so. It may as well be candidly admitted that in some instances the man with the misfire is strictly "up against it."

Although the cure of a misfire is difficult, uncertain and dangerous, the prevention is easy enough, or at least it is not difficult to load the charge in such a way that should a misfire occur it will not be necessary either to drill a new hole or to dig out the tamping in the old one. One way, of course, is not to put any tamping in, in which case it is the easiest thing in the world to insert another primer and try again, but this method is exceedingly expensive, as it is impossible to get the work out of dynamite in holes which are not tamped; in fact, it is necessary to very greatly overload them to get even a part of the work.

The other way, *and the right way*, is to place at least two primers in each bore hole. If the number of holes to be fired at one shot is very nearly as great as the number of electric blasting caps that the blasting machine will fire, only one of the primers from each hole is connected up, the other kept in reserve, so that in case of a charge missing fire, the second electric blasting cap can be connected up and fired. At first thought, this method may appear to be expensive and extravagant, but it is really much less so than it appears, because in the event that all the charges fire at first,

it is a proven fact that the second detonator far from being wasted really pays more than its cost by increasing the completeness of the detonation of the dynamite, and the amount of work done. Where large charges are loaded in each hole, as in sprung holes, it is customary to place one primer in the pocket and the other in the bore hole, and if the total number of electric blasting caps used are well within the capacity of the blasting machine, to connect them all up and fire them as if each were in a separate hole. This not only insures the explosion of each charge, but also insures the maximum possible efficiency of the explosive.

The fact that two detonators are able to get more work out of the dynamite than one was shown conclusively in the first blasts made in well-drill holes (holes usually 5 or 6 inches in diameter and 30 to 150 feet deep, drilled by a well drill). The old idea that one detonator was able to explode an indefinite amount of dynamite was shown to be erroneous, as frequently the top of the charge where the detonator was would explode and do good work, while unexploded dynamite would be found in the bottom. When two electric blasting caps were used, one near the top and one near the bottom, complete detonation of the entire charge was assured in moderate size holes and better work was done than with only one detonator, even when one left no unexploded dynamite. No well-drill holes are fired nowadays with but one electric blasting cap per hole, and not many with only two, for not only does the increased efficiency more than pay for the extra ones, but there is too much money value in explosives in a big well-drill hole to risk any chance of a misfire. Three, four and even more electric blasting caps are now frequently used in each charge in well-drill holes, and it is not improbable that the popularity that this method of blasting has enjoyed in recent years is due to the fact that not only the explosive is most thoroughly detonated by having several electric blasting caps in it, but also from the freedom from misfires which goes with this method of loading.

## THE BORE HOLE

It is well known that the *location, direction, size and depth* of the bore hole are important factors in the work done by explosives, and no proficient workman would attempt to locate a bore hole without first making a thorough examination of the structure, presentation and condition of the material to be blasted. With the comparatively recent advent of many explosives, differing widely in



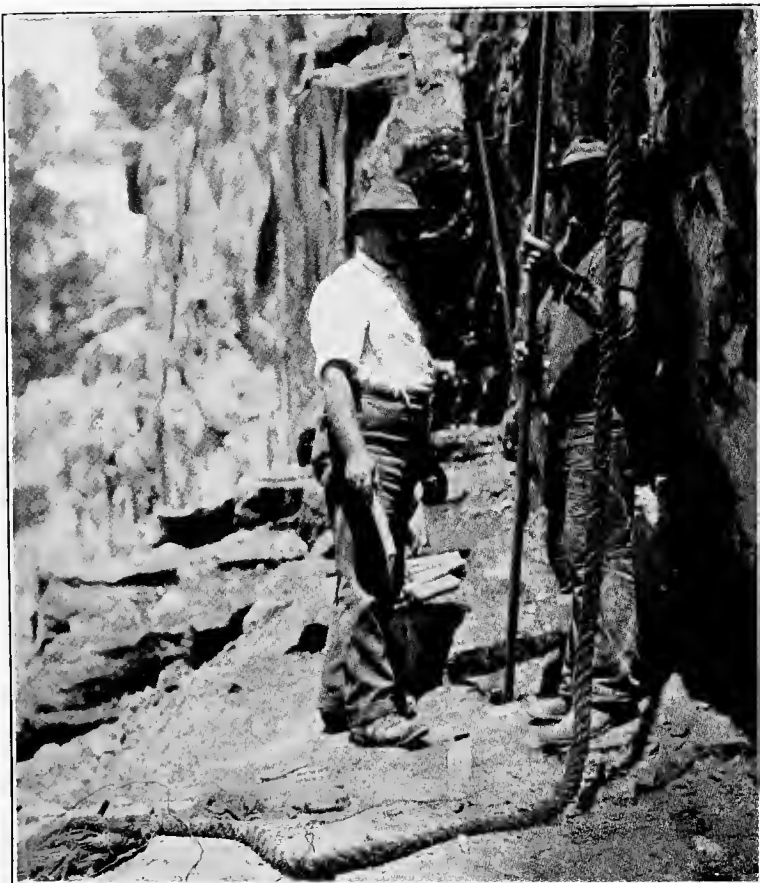
FACE OF A DRIFT IN ORE MINE SHOWING LOCATION OF BORE HOLES

their action, it has been found necessary to adjust the location and pointing of the bore hole in reference to the action of the particular explosive used. In some kinds of work, and particularly in coal mining, it is often necessary in order to secure maximum results to change the location and pointing of the bore holes when changing from one explosive to another. For instance, when blasting undercut bituminous coal with Carbonite or Monobel, the force of the explosive will often spread more and bring down more coal and larger lumps if the bore hole be started 12 to 18 inches from the rib, 2 to 3 feet below the top and pointed upward so that it will bring up close to the "top" at the same distance from the rib at which it was started.

### CHARGING

If water is running from the bore hole, load and fire as promptly as possible, and do not slit the cartridges unless gelatin dynamite or blasting gelatin is used. If it is necessary to use Monobel in wet work the bore hole should be swabbed out before loading and the cartridges should never be slit or broken.

A factor of great importance in the action of a charge of explosives is the "air space." High explosives used in rock blasting should always be loaded compactly in the bore hole so that no air space remains to act as a cushion when the charge is detonated and so reduce its breaking and rending effect.



LOADING A BORE HOLE ON A SHELF SIXTY FEET ABOVE QUARRY FLOOR

The best way to eliminate air spaces is to use dynamite cartridges which are just small enough in diameter to reach the bottom or back of the bore hole without jamming. In addition to using cartridges of the right diameter, it is a good plan to make a slit in the paper shells from end to end with a sharp knife, unless the work is wet. A cartridge of high explosives, only a little smaller in diameter than the bore hole, and with the shell slit, can be easily spread out with the tamping stick so that it will entirely fill the section of even a somewhat irregular bore hole, and can be relied on to give maximum efficiency when detonated.

The above does not apply always in coal blasting where, under

certain conditions, in the use of permissible explosives an "air shot" may give excellent results. In these shots, the air space between the charge and the tamping, with its cushion effect, results in a greater "spreading" of the pressure developed on detonation. These "air shots" sometimes break across the entire face when the same charge loaded without the air space would blow forward and bring down much less coal.

The cartridge should be pushed firmly and carefully into place with a wooden tamping stick having no metal parts whatever. If the primer is made with fuse and blasting cap it should be put into the bore hole last; if with an electric blasting cap, last or next to last. *Particular care should be taken to insure its close contact with the rest of the charge, and at the same time to avoid moving or shifting the fuse and blasting cap or electric blasting cap from its proper position.*

### TAMPING (STEMMING)

Although high explosives, particularly the higher grades, will give considerable local effect, even if fired with little or no confinement (as in "mudcapping" rocks or boulders), they will not give anything like maximum results under such conditions, or even in bore holes that are not thoroughly tamped to the mouth or "collar." Therefore, the only economical way to use explosives is to *entirely fill* the bore hole after the charge is in place with damp clay or similar material packed firmly into place. *It is very dangerous to use metal rods, or sticks with any metal about them for tamping, and an all-wood tamping stick should always be provided for the purpose.*

The following in regard to the advantages of confining explosives before firing them is quoted from United States Bureau of Mines Bulletin 423:

"Every explosive, when exploded, exerts pressure in every direction. When laid on top of a rock and exploded, gunpowder and other low explosives do not affect the rock, because they explode so slowly that the gases formed can lift the air above them and escape; but dynamite, fulminate of mercury, and other high explosives, if laid upon brittle or soft rock and detonated, may shatter it, because they explode so quickly that the gases formed cannot lift the large volume of air which confines them, without pressing back forcibly against the rock. This confinement by air is not, however, close enough to give the best result with any explosive. By boring a hole in rock and tamping the explosive firmly in it, gunpowder and other low explosives may be made to break the

rock, or a much less quantity of high explosives will break the rock than is required to break it when laid upon it. Confining an explosive is the cheapest and best way to use it."

To tamp a bore hole properly after the charge of explosives is in place, put in two or three inches of damp dirt or damp sand free from pieces of rock (never use fine coal or any other material that will burn) and tamp lightly. Pack the tamping material as firmly on top of the charge as can consistently be done without shifting the blasting cap or electric blasting cap in the primer. Then fill up a few inches more of the bore hole with tamping material, packing it in a little more firmly. After five inches covers the charge, the tamping may be pressed firmly into place without danger of premature explosion. *It is not safe to tamp by a blow any stronger than can be given by hand.* The firmer and harder the tamping is put in (without overlooking the above precautions) the better will be the results. If the bore hole is not properly tamped, the charge is likely to "blow out," or at any rate some of its force will be wasted.



TAMPING A BORE HOLE IN A QUARRY LEDGE

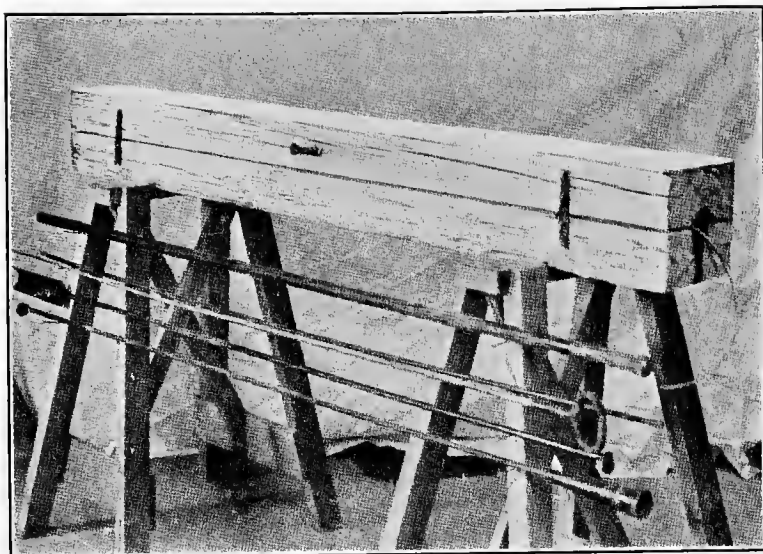
## AN EASY WAY TO OBTAIN PRACTICAL EXPERIENCE IN CHARGING AND TAMPING BORE HOLES

Reprinted from "Fuel," April 12, 1910. By Courtesy of "Fuel" Publishing Co.

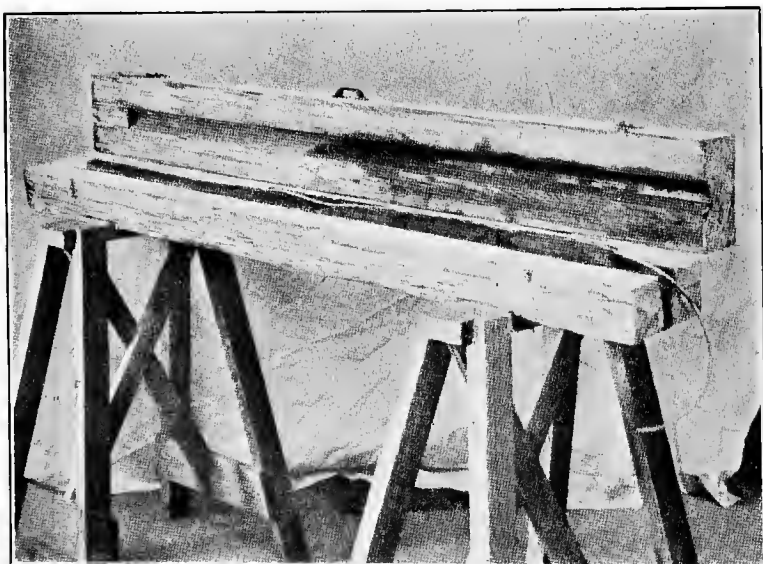
The use and abuse of explosives is attracting as much attention if not more than any one subject now being considered by mining men, whether considered from the standpoint of the miner or the operator. Elaborate and costly experimental plants have been installed within a few years by the manufacturers of explosives and by the U. S. Geological Survey at the Pittsburgh Testing Station to determine the properties of the common explosives used in mining and to demonstrate the proper method of using them. The charging and tamping of the holes drilled to break down coal or rock in a mine are matters of interest and importance, but too often these operations are poorly done, due to negligence, carelessness or inexperience. It is impossible to see inside a drill hole that has been charged to determine if the fuse has been broken or kinked, the blasting cap pulled out of the cartridge or to discover the other possible accidents that will occur to every practical man. In order to enable the students in Mining Engineering at the University of Illinois to practice charging bore holes and then have the charge inspected and criticised, a charging box or "artificial hole" has been built. This is shown in the illustration, page 70, and consists of a block of timber 8 inches square and 4 feet 6 inches long, with a hole 2 inches in diameter, drilled in the center. This block is sawed through the center, hinged and held firmly by clamps while the hole is being charged. It is then opened and the charge easily inspected. By varnishing and greasing the hole, the tamping is prevented from sticking to the wood when the top is raised. The "hole" is set on wooden horses and by raising one horse a bore hole inclined upward or downward can be obtained. Students are required to charge the hole, using different kinds of tamping, different explosives, and all of the ways of firing by squib, cap and fuse, and electric detonators. Sand or sawdust is used to represent black powder and dummy cartridges of inexplusive dope to represent the nitroglycerin explosives. The charge is examined and criticised by the class and by the instructor.

An experienced miner and former mine manager who was showing a class of students how to load the hole was very much surprised to find, upon opening the box, that the fuse was kinked into an S shape and broken.

By the use of this box the effect of using different kinds of



CHARGING BOX CLOSED



CHARGING BOX OPEN

tamping can be easily shown, the rate of burning of fuse in a hole can be tested and other experiments with explosives demonstrated much better than in the darkness of a mine where also the inside of the charged hole cannot be seen.

A glass tube was first thought of, but the glass breaks readily, is hard to clean from the tamping for another charge and, moreover, as the inside can be seen during the tamping, the actual conditions are not represented nearly as well as with the block.

The blasting box or hole, which can be easily made and is inexpensive, is adapted for demonstrating to inexperienced men at a mine the proper method of charging. It can also be used for demonstration purposes before mining institutes, etc.

### **SOME PRECAUTIONS IN LOADING DYNAMITE**

An explosive gives the best return on the investment when the burden is just a little less than its strength. Poor confinement, insufficient tamping and weak detonators all handicap the explosive—perhaps to the extent of causing a total failure.

To secure maximum confinement, use cartridges of a size that will go easily and without forcing to the bottom. If the standard size cartridges begin to stick, it is time to look at the drill bit gauge and compare the bits with it. Blacksmiths sometimes become careless about keeping the diameters up to full size. If the hole is dry and not unduly rough, slit the cartridges with a sharp knife (a case knife is best), drop them one at a time in the hole until it raises a couple of feet. Then press down with the tamping stick or lower the tamping block and drop it gently. It does not require a great amount of force to compactly pack dynamite in a bore hole, and it is neither necessary nor desirable to ram it with all your might. In well-drill hole loading, if the hole is full of water it is necessary to use a loaded tamping block, but it is not necessary if the hole is dry.

It is usually undesirable to slit the cartridges if the bore hole is very wet. The water fills the "air spaces" and is detrimental to the powder—unless it is a gelatin. If there is only a few feet of water in the bore hole, load unslit cartridges until they rise above the water.

In dry holes and above the water level, slit each cartridge once or twice, but do not twist the cartridge as that exposes the powder and allows it be smeared along the sides where it does no good and may give trouble.

If the holes are drilled through loose rock or top soil, it is a good thing to make a pit at the point where the hole is started; that is, to remove the loose material so that it will not fall down into the hole and make trouble.

In very deep well-drill holes, the first few cartridges may be lowered on a string tied to a wooden peg or skewer which is jerked free after the cartridge reaches the bottom. There is then a cushion on which the other cartridges may be dropped instead of on the hard rock. Water, of course, is cushion enough. A tripod, eight or so feet high, with a snatch block suspended from it, placed over the hole, makes tamping easier and safer in well-drill holes where a rope and block are used in place of a tamping stick. It also keeps the men who work the rope away from the hole. A precaution worth while in well-drill hole loading is to make the men who compose the loading gang take all matches and metallic objects out of their pockets while at the work, being particularly careful about blasting caps. If any of the gang have occasion to do block-hole or mudcap shooting at any time, they may keep a few blasting caps in their overall pockets and if one of these should fall down a big hole while being loaded, there would be a very great likelihood of a bad accident.

With short holes, tripod drill holes, etc., do not use too heavy a tamping stick. A husky man *ramming* dynamite with an oak pole 20 feet long and 2 inches in diameter is not a reassuring object. Pine or spruce is heavy enough. A bamboo fishing pole makes a good tamping stick for some work, is cheap, easily procured and straight—all desirable attributes, but particularly, it is light and is not as effective a battering ram as oak or hickory.

Test the electric blasting caps with a Du Pont galvanometer separately on important blasts and the whole circuit before firing. Test the blasting machine with a Du Pont rheostat to make sure it is up to capacity. Test each hole before the sand or clay tamping is put in so that another primer may be added in case a wire is broken.

In "lifters" or holes drilled horizontally or nearly so, and particularly when they are "sprung," a tube of zinc as large in diameter as will go in the hole and long enough to reach to the bottom will prevent the dynamite cartridges jamming in the hole. If the loading tube is not used the cartridges may be impaled on the small end of the bamboo pole and carried to the pocket or to the end of the hole. Do not slit cartridges used in sprung holes in hard rock. Many accidents have occurred in this work which

could only be attributed to particles of dynamite becoming punched, squeezed or rubbed between the surfaces of loose rocks.

Don't open the dynamite cases with a steel chisel or a rock. Use a wooden mallet and a wooden wedge. Not all of these precautions may seem necessary in every kind of work, of course, but their observance has a good moral effect on the men and teaches them to use care and caution in handling explosives.

## DISADVANTAGES OF SHORT FUSE

The object of using fuse for exploding powder or through the medium of a blasting cap, dynamite or other high explosive, is to allow the charge to be thoroughly tamped and confined, and after the lighting of the exposed end, by burning slowly and at a uniformly regular speed, to allow the blaster ample time to get to a place of safety before the charge explodes. To fulfil its whole object, the fuse must be long enough to extend from the charge to the collar of the drill hole and far enough out to allow time for the blaster to "take cover" after lighting the fuse. The fuse must extend to the collar so that the tamping may be done carefully and thoroughly, otherwise the whole of the explosive power is not realized and money value in explosive is thrown away.

It is the reprehensible practice of some miners to cut the fuse attached to the cartridge of explosive so that it is only 6 to 9 inches—or possibly a foot long; they light the fuse, and while it is sputtering, ram the cartridge into the bore hole, and "run like the deuce." They may, sometimes, throw in a light tamping, but their time is too short to tamp the charge thoroughly, as they realize that the locality is distinctly unhealthy for the time being.

Why do they do it? To save fuse, which costs anywhere from a third of a cent to a cent a foot.

By using a foot of fuse instead of 3 or 4 feet they save from one to three cents worth of fuse, but they waste as much or more than this in the value of the dynamite, because from lack of proper confinement and tamping only a part of the explosive power of the dynamite is realized. The danger of this operation is very great. In the open and unconfined, a foot of fuse of American manufacture takes about thirty seconds to burn, but in the bore hole, even when tamped hurriedly and incompletely, it is liable to burn faster, and it is a close race between the fuse and the blaster, whether the latter will be caught or not.

What good will it do the miner to save a few cents a day on



OPEN IRON ORE MINE IN CUBA

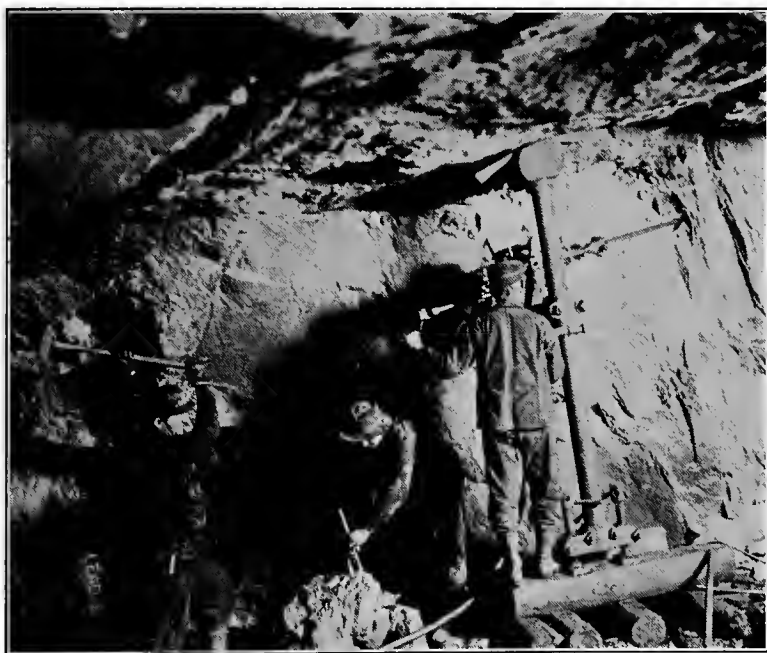
fuse while he is losing several cents a day on wasted dynamite, if he eventually gets killed or injured?

This practice is called using "short" fuse; it is wasteful of explosives, it is dangerous, and in the long end, it is liable to be very expensive either to the miner or to his family.

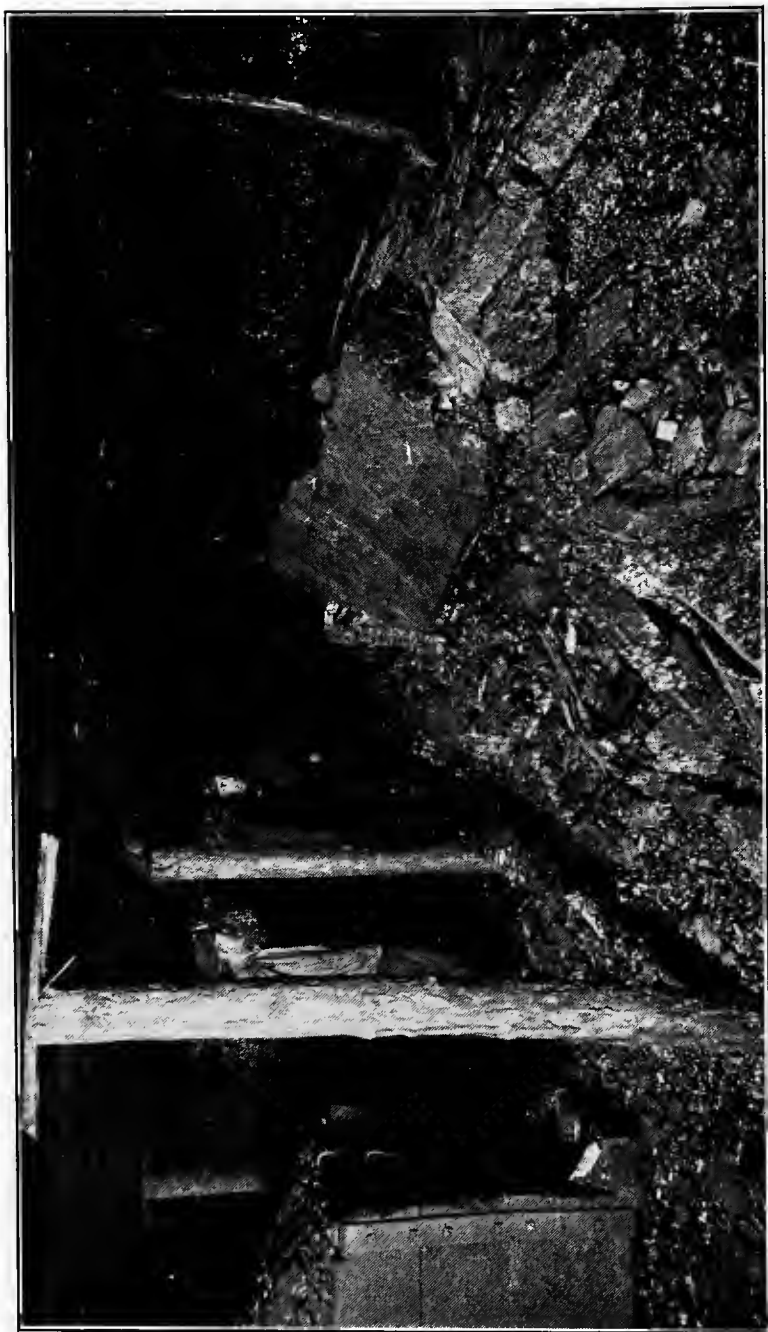
## WORK IN WHICH HIGH EXPLOSIVES ARE USED

### ORE MINING

Different methods of blasting ore are necessary in different places in order to meet the various conditions of formation, hardness, etc., encountered, some mining being by "stoping," other by "slicing and caving," and still other by stripping off the surface and taking out the ore in the open. In underground work holes are drilled from 3 to 6 or 7 feet in depth, according to the hardness



DRILLING THE BREAST IN A GOLD MINE



MONOBEL SHOT IN AN ALABAMA COAL MINE

of the ore and the size of the stope or drift. In some places a vertical and in others a horizontal "cut" is first blasted out of the face and the necessary squaring up shots are fired afterward.

If the ore is unusually hard and the work very wet, the explosive should be gelatin dynamite of 60 per cent. to 80 per cent. strength, or blasting gelatin. These should be exploded with a No. 6 (red label) or stronger detonator. If the ore is not unusually hard, use 35 per cent. to 60 per cent. gelatin dynamite. In comparatively dry mines Red Cross Extra Dynamite is especially recommended because of its low freezing properties. In open ore mining bore holes should be chambered or sprung with 30 per cent. or 60 per cent. dynamite and then charged with blasting powder or Du Pont R. R. P., according to the character of the ore and location of the bore holes. Blasting powder is not satisfactory in wet work.

## COAL MINING

In comparatively dry coal mines where neither gas nor dust occur in dangerous quantities, blasting powder is largely used. Where gas and dust exist it is a mistake to use any blasting agent other than a permissible explosive. The permissible explosives are those which have been tested by the U. S. Government and recommended for blasting in gaseous and dusty coal mines. If used according to instructions these explosives should not ignite mine gas or coal dust.

Excepting in very wet work Monobel is the best explosive to use in gaseous or dusty coal mines. It is made in six grades: No. 1, No. 2, No. 3, No. 4, No. 5 and No. 6.

Monobel No. 1 and Monobel No. 6 are the quickest, with Monobel No. 2 and Monobel No. 4 next, and are intended for hard shooting anthracite coal or bituminous coal for coking, which should be well broken up. Monobel No. 3 and Monobel No. 5 are very slow, and if properly used will not break up the softest and most friable coal any more than will blasting powder. Although Monobel may freeze, it is not necessary to thaw it (except Monobel No. 3, which must be thawed when frozen), because its composition is such that it can be detonated just as well when frozen as when thawed. If in cold weather the cartridge in which the detonator is to be placed is hard, the end can be crumbled with the fingers so that the detonator can be easily inserted. Monobel No. 4, Monobel No. 5 and Monobel No. 6 will remain unfrozen at temperatures which freeze the other grades. Unless the work be quite dry, it is



CARBONITE SHOT IN WEST VIRGINIA COAL MINE

best not to slit Monobel cartridges. Monobel usually has more of a spreading effect and is less shattering if the cartridges do not completely fill the back of the bore hole and an air space be left around them, because this air space acts as a cushion when the Monobel is detonated. When blasting in this way it is a good plan to use cartridges considerably smaller in diameter than the bore hole—say a  $1\frac{1}{4}$ -inch cartridge in a bore hole that would take a  $1\frac{1}{2}$ -inch cartridge, or a  $1\frac{1}{2}$ -inch cartridge in a bore hole that would take a  $1\frac{3}{4}$ -inch cartridge. Conditions met with in blasting coal differ greatly, and as it is necessary to accommodate the location, direction and depth of bore holes to these conditions, it is impossible to give any general rule in regard to them.

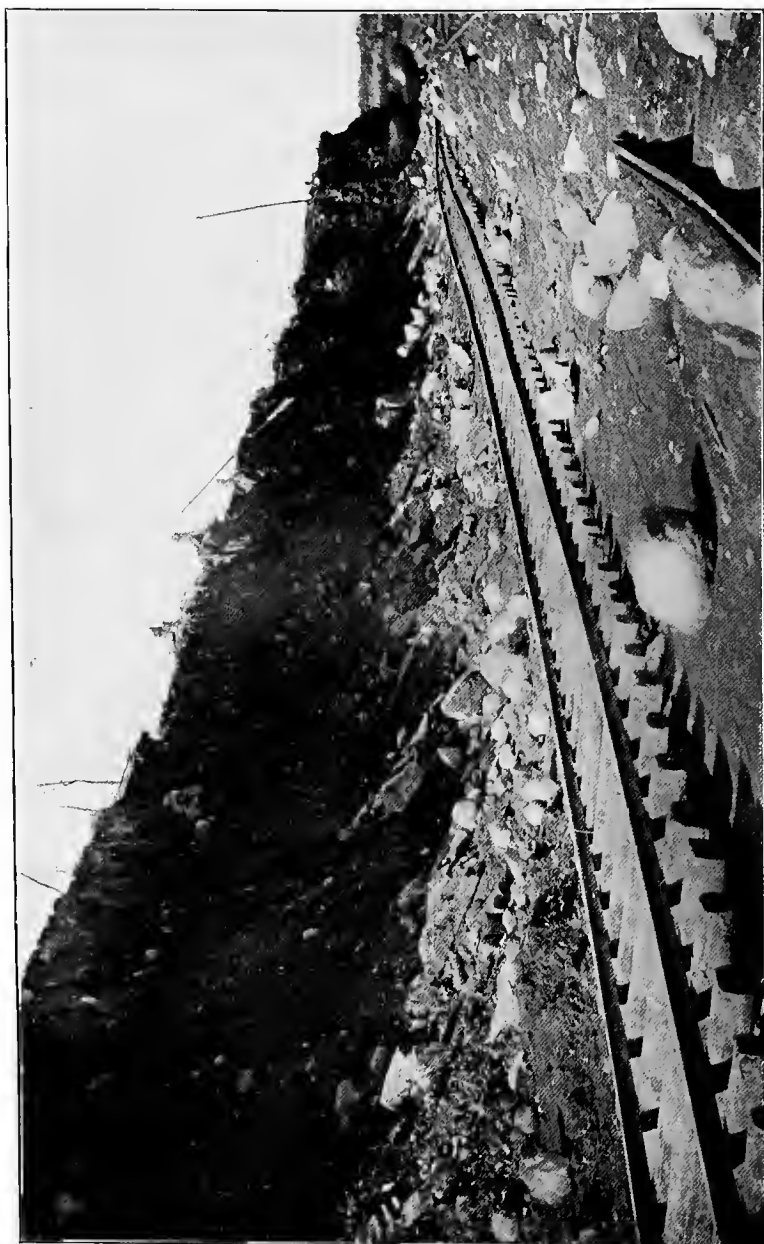
When coal mining is *very wet* and a permissible explosive is necessary, blasting should be done with one of the Carbonites. Unless the work is exceptionally wet there is no disadvantage in slitting the Carbonite cartridges if the shot is fired immediately after the bore hole is charged and tamped. Carbonite No. 1, No. 2, No. 3 and No. 4 freeze at temperatures between 45° F. and 50° F., and cannot be properly detonated unless they are thoroughly thawed. Carbonite No. 5 and No. 6 are the low-freezing grades and are not readily affected by cold. Carbonite No. 1 is the most shattering and No. 4 the least, while No. 2 and No. 3 rank between these. Carbonite No. 5 corresponds in action to Carbonite No. 2 and Carbonite No. 6 to Carbonite No. 3.

## STRIPPING

The removal of the surface from beds of ore or coal which is commonly called stripping, does not differ materially from other large excavating work, and explosives are used in much the same way as they are in railroad construction, quarrying, etc.

It is usually the custom in stripping work to drill holes 16 to 20 feet deep, spring or chamber these with ten to thirty pounds of 30 per cent. to 40 per cent. Red Cross Extra Dynamite and then charge, if the work is dry, with from four to twelve kegs of blasting powder, or the same number of  $12\frac{1}{2}$ -pound bags of Du Pont R. R. P., if the work is damp. If the work is wet, Red Cross Dynamite will give best results.

Sometimes, when the material to be moved is earth or shaly rock, tunnels just large enough for a man to crawl into are driven into the bottom of the face, and large charges of blasting powder or Du Pont R. R. P. are placed in cross cuts or chambers at the inner ends of these tunnels. Occasionally cross cuts are also driven



MICHIGAN IRON ORE STRIPPING

half way back and charges of explosives located there also. The tunnel is filled up completely in front of the charges with earth packed in as tightly as possible. These charges are fired electrically, nitroglycerin dynamite being used for a primer. This system of blasting is known as "gopher holing." A similar plan with larger tunnels and headings is also practised occasionally in ballast quarries and very heavy railroad cuts.

It is frequently necessary to resort to blockholing or mudcapping in stripping operations. These are described in the section on "Quarrying."

## **RAILROAD CONSTRUCTION**

Many kinds of blasting are necessary in railroad construction, and accordingly different explosives must be selected, and they must be used in different ways. In open cut work it is generally best, when in rock, to use dynamite from 30 per cent. to 60 per cent. strength, depending on the hardness of the rock. To blast in clay or shale, use Du Pont R. R. P., or blasting powder, after the holes have been chambered or sprung with 40 per cent. dynamite. If the work is wet use Red Cross Straight Dynamite, but if very wet use Red Cross Gelatin.

Red Cross Straight Dynamite is best for "mudcapping" or "blistering."

Proper location and depth for bore holes in this kind of work can be determined only by careful examination and study of conditions.

## **CANAL DIGGING**

Conditions met with when digging canals are generally similar to those encountered in railroad construction. The suggestions in regard to the use of explosives in railroad construction may, therefore, be applied to canal digging.

## **TUNNEL DRIVING**

The best explosive to use and the proper location and pointing of bore holes in tunnel driving is dependent on the size and shape of the tunnel and the kind of rock encountered. Large tunnels are driven in two horizontal sections, the upper one being known as the heading and the lower as the bench. The heading is practically a smaller tunnel and is driven in the same way as a tunnel of that size would be, while the bench is shot down with charges placed in vertical holes drilled back of the face or lifted up with charges in horizontal holes drilled into the bottom of the face.



BLAST ON RAILROAD WORK SHOWING ROCK AND EARTH LIFTED HIGH IN THE AIR



DRIVING A MINE TUNNEL

Small tunnels, and headings in large ones, are usually drilled so that a vertical wedge can first be blasted out of the middle of the face. Relief holes which widen and square up this wedge are next shot and then the blasting of rib or side holes and top holes and bottom holes brings the tunnel to the proper size.

In ordinary rock 50 per cent. to 60 per cent. gelatin dynamite should be used, while very hard rock will be broken up better if blasting gelatin makes up part of the charge in the cut and relief hole.

## QUARRYING

Blasting powder is generally used for blasting dimension stone, but satisfactory results can often be had by using light charges of 25 per cent. to 30 per cent. Red Cross Extra Dynamite, in cartridges considerably smaller in diameter than the bore hole. In this work particular care should be taken to leave a considerable air space between the charge and the sides of the bore hole. If the work is very wet, use 25 per cent. or 30 per cent. Red Cross Dynamite.

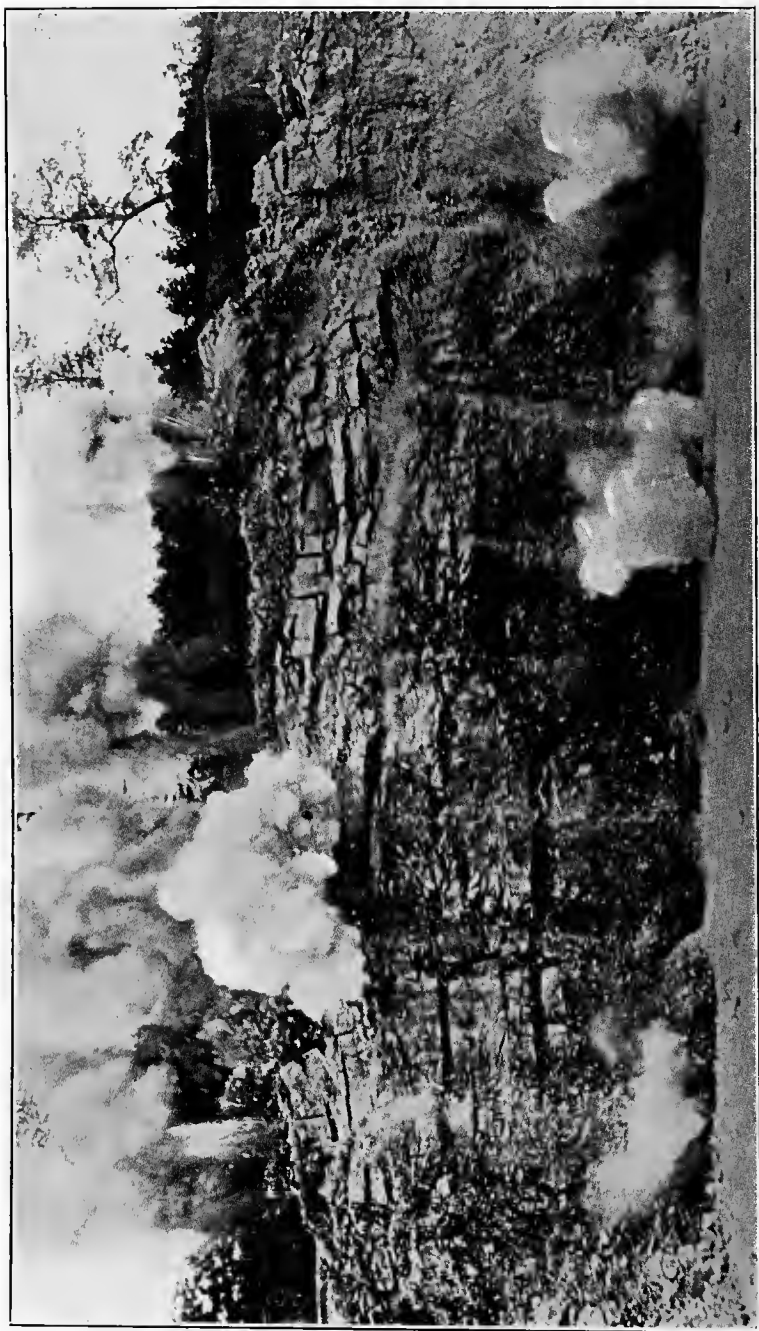
In quarries producing ballast, cement rock, limestone or other material which should be well broken up, 40 per cent. dynamite is the best explosive to use, unless the rock is exceptionally hard or



GAMBOA, LAST PANAMA DIKE, REMOVED BY 40-TON BLAST OF DYNAMITE. THIS BLAST, SET OFF BY PRESIDENT WILSON IN WASHINGTON, WAS THE LAST STAGE IN THE COMPLETION OF THE PANAMA CANAL



TUNNEL FACE READY TO BLAST—PRIMED WITH BLASTING CAP AND FUSE



BLASTING IN A QUARRY

the work very wet. Under these conditions 40 per cent. to 60 per cent. dynamite should be used. In deep bore holes where the rock is not very hard, Du Pont R. R. P. has given excellent results. It is sometimes of great advantage to use some blasting gelatin in the bottom of deep bore holes in hard rock, or in that part of the bore hole which penetrates the hardest stratum. Bore holes (excepting well-drill holes) are usually located from 6 to 10 feet back of the face, spaced from 5 to 8 feet apart and drilled from 6 to 20 feet deep, according to the nature of the rock and other conditions. If a double row of holes is drilled so that they will be alternated or "staggered" and all are fired at once, the material will be broken up considerably better than with a single row.

In quarries or other work where fissures or seams occur in the rock, considerable drilling can be saved by taking advantage of these seams and loading the explosives into them. It is usually necessary to open up the seam first by firing a small charge of explosives in it. To do this the wrapper or shell should be removed from the cartridge and the explosive pressed as far as possible into the seam with a flat stick. This charge is primed by pushing the blasting cap (which has already been crimped to the necessary length of fuse), into the charge with the flat stick. Tamping may or may not be used.

Rock which has been blasted out in blocks too large to handle is broken up by "blockholing" or by "mudcapping" (sometimes called blistering, bulldozing or doby shooting). Blockholing saves explosives and mudcapping saves drilling and time. In "blockholing" a hole is drilled into the rock deep enough to hold the requisite quantity of explosives and tamping. The amount of explosives necessary depends entirely on the size, shape and quality of the stone to be broken. The explosive should be removed from the shell and packed into the bore hole with a stick. This charge can be detonated with either an electric blasting cap or a blasting cap and fuse. Red Cross Straight Dynamite is recommended for this work.

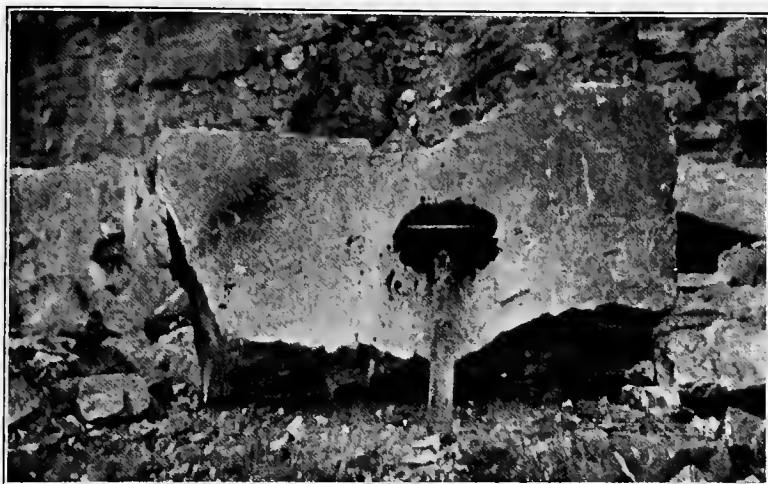
In "mudcapping," the charge may range between a half cartridge and several pounds, according to the size, shape, structure and hardness of the stone. The cartridges should be slit and packed in a mass as close to the surface of the stone as possible, on a flat or hollow side of the stone, and if practicable, in such a position that the force of the explosive will be exerted along the cleavage and at a right angle to the stratification. The charge should then be covered with a mass of stiff clay pressed down as firmly as possible.



LIMESTONE BLASTED WITH DU PONT EXPLOSIVES

The best explosives for mudcapping stone are 40 per cent. to 60 per cent. Red Cross Straight Dynamite.

A special quarry book is in course of preparation. A copy will be sent free on request.



MUD CAP ON THE SIDE OF THE STONE



THE RESULT—THIS SHOWS THAT DYNAMITE “WORKS” EQUALLY IN ALL DIRECTIONS



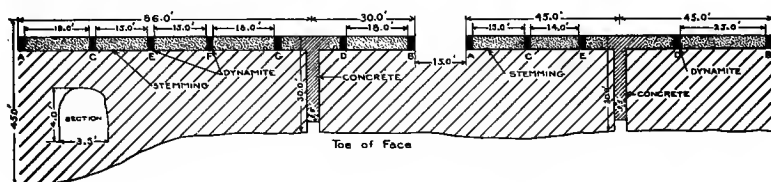
“GOPHER HOLE” READY FOR CHARGING



“GOPHER HOLE” READY TO BLAST

## TUNNEL BLASTING

One of the most economical methods of blasting rock is that known in the East as the "tunnel blast" and in the West as the "gopher hole." The amount of explosive used in each blast is very large, and it is necessary to use the utmost care not only in the placing of the charge, the selection of the explosive, both the quality and quantity, but also in the electrical connections, which must be frequently and thoroughly tested during loading, so that there is no possibility of a misfire.



One of the most successful of these blasts made recently was in a large limestone quarry where two tunnels were driven straight into the face of the rock, each branching at right angles both ways at the end of the main tunnels, each branch being driven 30 to 40 feet in three instances, and about 90 feet in the other. The tunnels that were driven straight into the rock were 30 feet long, about 3 feet wide and 4 feet high. The cross-section of the cross-cuts was the same. In these cross-cuts the explosives, about equal parts of Du Pont Straight 60 per cent. strength and Du Pont R. R. P., were loaded, three electric blasting caps being placed in the 60 per cent. dynamite in each charge of explosive. Each separate charge of explosives consisted of 1,000 to 2,000 pounds. These were placed 15 to 20 feet apart, with the intervening distance filled with broken rock, sand, muck and dirt. In the two cross-cuts from the two tunnels the explosive was charged in twelve divisions, no explosive being placed in the main tunnels, which were filled up solid with concrete. All the electric blasting caps were connected in parallel to large-sized leading wires carried into the cross-cuts. About 15,000 pounds of explosive, costing \$1,376.25, brought down 50,000 cubic yards (estimated) of rock, at a cost of about  $2\frac{3}{4}$  cents per cubic yard. The firing was done with a power circuit delivering a 30-ampere current at 110 volts. The cost of driving the 266 feet of tunnel was about \$400. The rock was broken up so well that very little subsequent blasting was required to get the rock into the size desired.

Tunnel blasting is not well adapted for work in those quarries where the rock is of such character that the tunnel roof will not hold up without timbering, as this increases the cost too much; neither is it recommended in quarries situated in populous districts, not on account of the concussion, but because hidden fault in the rock might result in the rock being thrown so far as to cause damage.

### **ADVANTAGES OF WELL-DRILL HOLES**

What is commonly called a well-drill hole is one driven through rock or earth to any depth desired, and usually from 5 to 6 inches in diameter. Well-drill holes for blasting are not often less than 30 feet nor more than about 150 feet in depth. The machine which is used for drilling was originally designed for oil-well and water-well drilling, and machines for these purposes can sink a hole to a depth exceeding 2,000 feet.

The well driller is a self-contained machine, usually with its own steam or gasoline engine on wheels, sometimes able to move from place to place by its own power. The drilling is accomplished by lifting a heavy cutting bit, weighing 1,000 pounds or more, and dropping it on the rock, the engine or motor being of such size as to make possible about fifty or sixty blows per minute. This is quite different from the ordinary air or steam tripod drill, where a comparatively light bit is driven by steam or air pressure against a rock. With the tripod drills, the depth of the hole is limited by the length of the bit and it is not usually economical to have them longer than 25 or 30 feet in length. With the well-drill machine, the bit is suspended by a rope or cable, so that the drilling bit is the same size for any depth hole desired, the deeper the holes the more rope being paid out from the machine.

The system of drilling big holes, or well-drill holes, as they are sometimes called, has some advantages and some disadvantages over the tripod drill.

Some of the advantages are: A well-drill hole can be put down the entire depth of the quarry face. It can be made of such a size as to contain very large charges of explosive without springing. The well-drill machine can run when operated by steam or gasoline after the main power plant and air pressure are shut down for the winter. On account of the larger diameter of well-drill holes, it is possible to place them farther apart and farther back from the face than would be possible with the tripod drill, and to bring down a very much larger quantity of rock. It is not always necessary to strip the earth from the top of the rock with the well-drill machine

as it is with the tripod drill, and there is a considerable element of safety in not having a high face of rock worked off in benches, with the men cleaning the benches and endangering the loaders below by falling rock.

On the other hand, the tripod drill is much easier moved from place to place, can be easily put up on irregular places, and can drill a hole in any direction—up, straight in, slanting downwards or straight downwards, whereas the well-drill machine is limited to one position only, which is straight down.

Blasting in well-drill holes doubtless effects a considerable saving in explosive, at least for the initial blast. The amount of secondary blasting, such as mudcapping and blockholing, necessary after a widely spaced well-drill blast, will depend on the character and stratification of the rock. Not every kind of quarry is adapted for well-drill blasting, either on account of the angle of the stratification or the nearness of the quarry face to other property, which may be injured by flying fragments, although this latter is possible to guard against by intelligent spacing and loading of the holes.

## CLAY BLASTING

The use of explosives in this line of work has excited so much interest among clay producers that we have issued a special booklet on the subject. A copy will be sent on request.

*Du Pont Co., Wilmington, Del.:*

*Gentlemen:*—Two or three months ago the best customer we have, a large manufacturer of clay flowerpots, ceased sending us his orders. We were astounded because we had given him what we thought an A1 product, and good service in every respect. Inquiry, however, developed that he was dissatisfied with our clay because we had been giving him the top layer.

Our method of working our clay had been to dig it out by hand labor with pick and shovel, and when we found it necessary to create a face so that the entire depth of our vein would be available we were in a quandary as to how to do this at a cost which would let us come out whole.

One of our officials had been reading of some of the wonderful things the Du Pont Company had been advocating in the way of land work, plowing, ditching, etc., and the idea occurred to us that dynamite might answer our problem.



BLASTING IN DETROIT RIVER



COLONIAL IMPROVEMENT COMPANY CLAY PIT

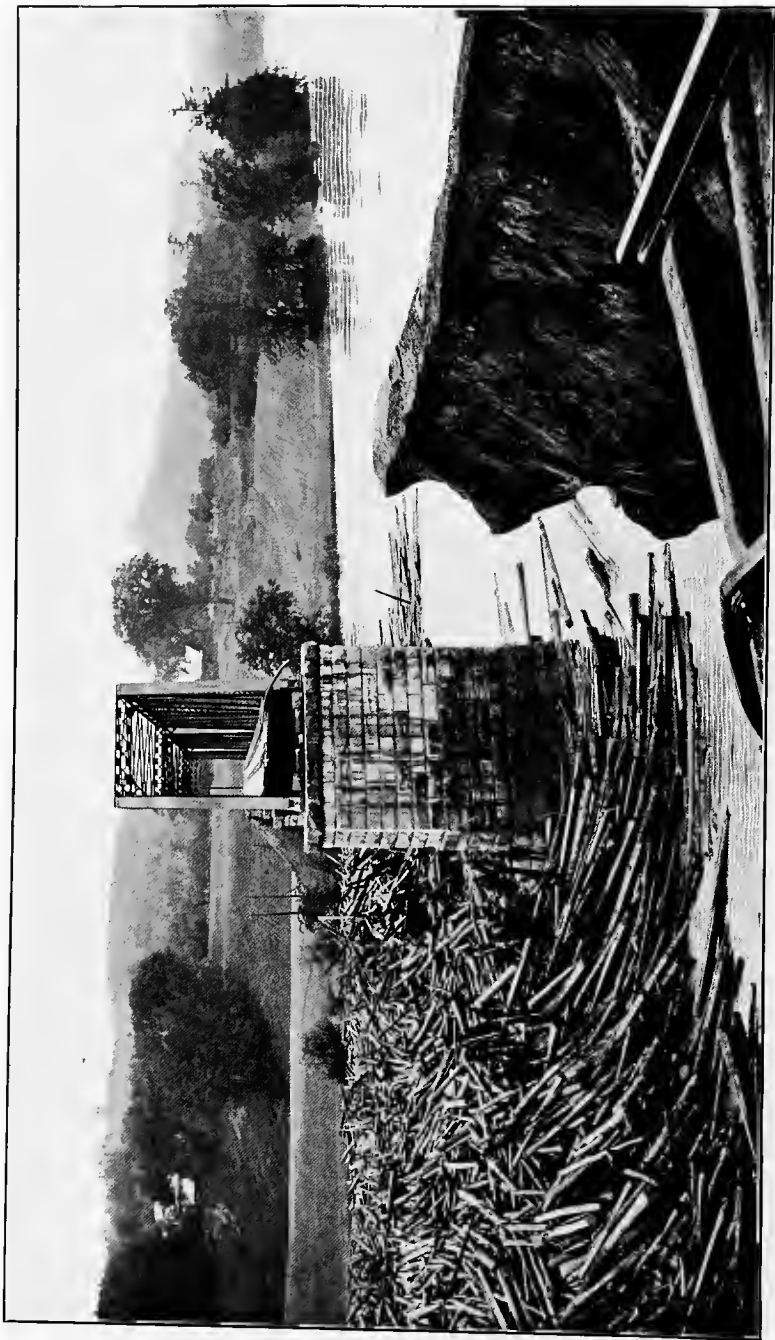
Our working was in the form of a shallow basin. As an experiment we employed a blaster to place four shots about 10 feet back from one of the edges of the basin. The result was one of the most perfect faces for clay working that can be imagined. The cost of these four shots was exactly \$4, and it resulted in our regaining a customer to whom our sales average at least 1,000 tons a month.

Further, the use of dynamite has enabled us to more than double our output without hiring one additional man.

FRED C. McCALL, *Secretary*,  
Colonial Improvement Company,  
Wilmington, Del.

### SUBMARINE EXCAVATING

It is generally the custom to use drill boats equipped with steam or air drills when blasting ledges and other rock in the bottoms of harbors and streams unless there is not sufficient work to warrant the installation of such an equipment. In that case it is customary to have divers fasten "torpedoes" or bundles of high explosive cartridges on or under abutting points of reefs, these "torpedoes" being afterward exploded by electricity. It is usually necessary to repeat this process several times before there will be much effect on the ledge, and accordingly this method of submarine blasting cannot be considered economical, and should be resorted to only when necessary.



BRIDGE CARRIED AWAY BY A LOG JAM

The usual and best way to use a high explosive under water is to load it in holes drilled from stagings or drill boats. Drilling is generally done through pipes or tubing from 4 to 8 inches in diameter, the purpose of this tubing being to steady the drill and keep it in position. In order to secure the same results under water as would be had on land it is necessary to locate the bore holes closer together and charge them more heavily, as the weight of the water tends to counteract the effect of the explosive.

Submarine bore holes in deep water should be charged by divers. Charging in comparatively shallow water may be done from the surface of the water through the tubing with a long tamping stick or by means of an implement known as a "charger," which is especially designed for the purpose. When working close to wharves or vessels, bore holes should be drilled closer together and light charges used to prevent damage. Submarine firing should always be done electrically, as even the best fuse is not certain after having been under water a little while. Electric blasting caps especially designed for submarine work are much the surest and Du Pont Submarine is recommended. To allow the proper margin of safety it is advisable to use the No. 8 strength of these electric blasting caps. The proper explosive to use for submarine blasting is 40 per cent. to 60 per cent. gelatin dynamite, or if the rock is extraordinarily hard, blasting gelatin. Any of these explosives can be put up if so desired in cartridges up to 5 inches in diameter, and 32 or 36 inches long. The paper shells of these cartridges are extra heavy.

## **DESTROYING WRECKS**

Wrecks of wooden or steel vessels can be completely broken up by high explosives. The charges must be placed by divers and anchored in position if water currents are strong. Firing must be done electrically. Sunken masts may be cut off under water by lowering a ring of high explosives made by tying cartridges to a properly weighted wooden or iron hoop, down over the top of the mast to the required distance and firing electrically. Gelatin Dynamite will give best results in this work.

## **STARTING LOG JAMS**

To start log jams with dynamite the charge of several cartridges or in some instances of many pounds of dynamite is exploded on or under the logs forming the key of the jam. When small



BLASTING AN ICE GORGE IN THE SUSQUEHANNA RIVER

charges are enough, the cartridges are tied in a bundle as when blasting ice. If charges of fifty pounds or more are necessary the dynamite may be put in a bag or left in the original wooden cases. The charge is primed with a Du Pont Waterproof Electric Blasting Cap and after being firmly secured in the proper position, is exploded from the shore with a blasting machine.

Blocks in log rollways caused by rain and snow freezing and binding the logs together are broken up by exploding charges of dynamite in different places under the logs until they are loosened and can be rolled apart.

Red Cross Extra Dynamite 40 per cent. is recommended for starting log jams and for opening the rollways.

## BLASTING ICE

Ice gorges may often be prevented by shattering the large floating cakes with Red Cross Extra Dynamite 40 per cent. so that they will not lodge at dams or in the narrow parts of the stream. To break these cakes several cartridges of the dynamite tied together in a bundle are laid on the ice and exploded. This is repeated until the cake is thoroughly shattered and broken up. The size of the charge and the number of times the blasting must be repeated depend altogether on the thickness of the ice and the size of the cake. One cartridge of the bundle is primed with blasting cap and fuse, but before this the dynamite must be thoroughly thawed and kept thawed until it is laid on the ice. This blasting can be done best along broad, slow-moving parts of the stream where it is easy to get on to the ice cakes either from the shore or from boats. When the streams are narrow the charges of dynamite may be thrown on to the ice from the shores, or, if the ice is running swiftly, they may be dropped on to the cakes from the downstream side of bridges. When the charges consisting of two or more cartridges tied together in a bundle are to be thrown on to the floating ice either from bridges or the shore a block of wood, piece of board or something of that kind should be tied to the charge to keep it from rolling out of position after it lands on the ice. As it is necessary when blasting ice in this way to light the fuse while the dynamite is in the hands of the blaster, particular attention must be given to having the fuse plenty long enough and the charge must be thrown just as soon as the fuse is lighted.

The following table gives the approximate quantity of Red Cross Extra Dynamite 40 per cent. required to break floating ice

cakes of different thickness when the dynamite is exploded on the surface of the ice. The number of charges necessary depends on the size and extent of the ice cake:

Thickness of Ice Cakes	Approximate No. of 1 1/4" x 8" Cartridges
12 inches.....	2 to 3
24 inches.....	6 to 8
36 inches.....	10 to 12



To open ice gorges already formed, a channel should be cut through them beginning on the downstream side and working up stream along the line of the strongest current. In large streams this channel should be about 50 feet wide, and if the gorge does not move after the channel has been cut through, it will then be necessary to begin at the downstream side of the gorge again and widen the channel until the ice has been carried away.

To make the channel, holes are cut with an axe, bar or ice spade through the ice 20 to 30 feet apart. These holes are laid out in a semi-circle with the two end holes about 20 to 30 feet back from the open water and 50 feet apart.

The charge consists of several 1 1/4 x 8-inch cartridges of Red Cross Extra Dynamite 40 per cent. tied securely together with string, one of the cartridges having been primed with a Du Pont Waterproof Electric Blasting Cap. When the charges for all of the holes are prepared they are connected together and to the leading wires. Each charge is then lowered by ropes into the water and pushed under the downstream ice with the tamping stick. If the

current is strong enough to carry the charge down stream the electric blasting cap wires should be long enough to let it float 6 or 8 feet below the holes. In a slow current a block of light wood may be fastened to each bundle of cartridges to make it float against under side of ice. The explosion of all of these charges simultaneously by the operation of the blasting machine will break up the first 50 or 60 feet of the channel and the broken ice will immediately float away unless the current of the stream is very sluggish. In that case the broken ice should be pushed out with poles into open water, before it has time to freeze in place again. This same operation is repeated, cutting out 50 or 60 feet or more of the channel with each blast until the gorge has been cut through. If the ice is from 2 to 4 feet thick the charge in each hole should be from two to five  $1\frac{1}{4}$  x 8-inch cartridges of Red Cross Extra Dynamite 40 per cent. In ice 6 to 8 feet thick, each charge must be increased to ten or twelve cartridges. When the ice is thick, and large charges are necessary, the holes have to be from 6 to 12 inches in diameter in order to get the bundle of cartridges through them. These large holes can be cut through the ice more easily by exploding half cartridges of the dynamite in small holes made with bars.

In this work particular attention should be given to having the dynamite in a well-thawed and soft condition when it is used, and to guard against breaking insulation of electric blasting cap wires or their withdrawal by the pull of the current.

Ice is blasted from watering places for stock either by exploding the dynamite on the ice or in the water under the ice.

## **BREAKING UP OLD MACHINERY AND BOILERS**

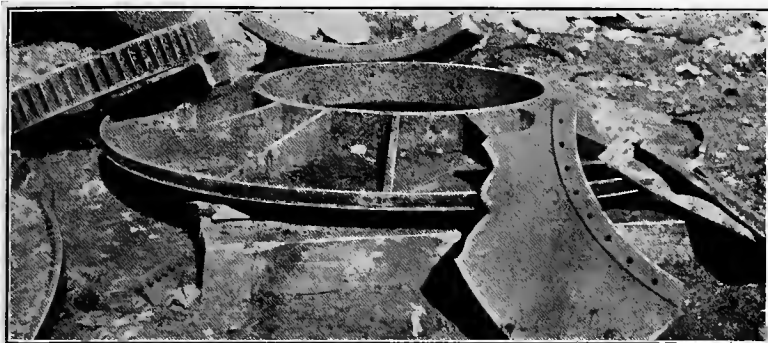
Metal castings can be broken up by firing charges of explosives on their surface as is done when mudcapping large rocks (see paragraph on "Quarrying"). The most economical method, however, is to drill holes in them and blast exactly as described under "Block-holing," also explained in the paragraph on "Quarrying" in this catalogue.

To cut up old boilers the dynamite should be removed from the wrapper or shell and laid in a compact train along the line of the desired cut or shear. This train should not be flattened or spread out laterally any more than necessary and should have a cross sectional area of say seven-eighths of a square inch. That is, a  $1\frac{1}{4}$  x 8-inch cartridge should make about 16 inches of the train. The train should be covered carefully so as not to break it, with



GRADING A ROAD

well-tempered stiff clay pressed firmly around the explosive and should be detonated with a blasting cap crimped to the necessary length of fuse. If this is properly done the boiler plate will be cut through as with a shear. Bolt heads can be blown off very easily by firing a small charge of dynamite on them after it has been carefully covered with damp clay. Du Pont Straight Dynamite of 40 per cent. strength is recommended for this work.



THE CHARGE OF EXPLOSIVES PROPERLY MUDCAPPED



THE RESULT

## ROAD BUILDING

Road building and ditching always take more or less digging, but by using dynamite to loosen up the hard ground or shale, and to blast out the rock, roads can be built quickly and at reduced expense.

We have issued a special book on road building which covers all the more important phases of the subject in a thorough manner. The book does not confine itself to discussing and explaining the use of explosives in road construction; but forms a quite comprehensive text-book on the whole general subject. A copy of this book will be sent on request. Ask for Road Building Book.

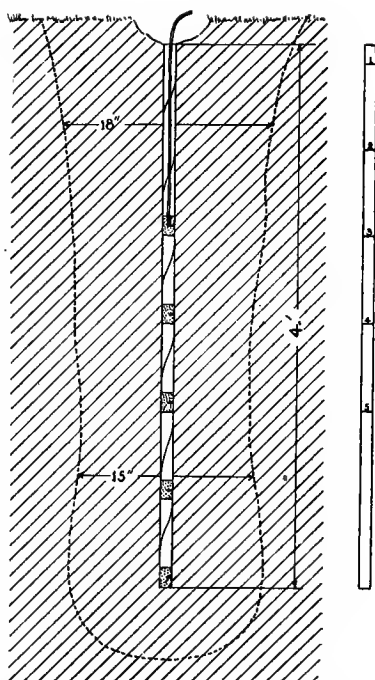
## **SINKING WELLS**

Wells are generally sunk through rock or ground which cannot be dug to advantage without the aid of explosives. In well sinking when rock is reached and the earth or sand above is properly supported, a circle of four or five drill holes should be started about half-way between the center and the sides of the well and pointed at such an angle that they will come closer together near the center when they are 3 or 4 feet deep. These holes should be loaded about half full of Red Cross Extra Dynamite 40 per cent. with damp clay or sand tamping packed firmly above to the top of the hole and then exploded all together from the surface by electricity. The result of this shot will be to blow out a funnel-shaped opening in the center, and the bottom can then be squared up with another circle of holes drilled straight down as close to the sides as possible. If the well is large it may be necessary to drill a circle of holes between the inner and outer circle. The above process should be repeated until the well has passed through the rock or has been sunk to the necessary depth. Do not in any case enter a well until all the fumes of the last blast have come out. If in doubt, lower a lighted candle to the bottom; if it continues to burn the well may be entered safely.

## **BLASTING TELEGRAPH AND TELEPHONE POLE HOLES WITH DYNAMITE**

A new method has been developed for digging holes with dynamite for planting telegraph and telephone poles. The original method was to clear away about 6 inches in depth of the earth at the surface, bore a hole with an auger to the required depth, and fire a small charge of dynamite in the bottom with blasting cap and fuse. A modification of this method was to repeat the operation, making the first blast at half the required depth, and the second blast at the depth desired. A new method, which does not require as much cleaning out as the older method, is to fire one or more cartridges of dynamite, cut up in halves, thirds or quarters,

and spaced at even intervals in the bore hole, firing by means of a blasting cap and fuse, or an electric blasting cap and battery, the detonator in either case being placed in the top cartridge. This fires all the sections of dynamite by the concussion traveling from one section to another, producing, when properly spaced and loaded, a hole of the required depth and diameter, with no subsequent "digging out." Where no water is encountered, Red Cross Extra 40 per cent. Strength is the explosive recommended. In wet land and where the holes are liable to contain water, either Red Cross Straight 40 per cent. or Du Pont Straight 40 per cent. will give excellent results, although the latter requires to be thawed in cold weather.



The dynamite method for digging telephone and telegraph pole holes, not only costs less than hand digging, but it is much quicker, especially in hard soil. There are two methods by which the sections of dynamite cartridges are spaced; one by making a tube of heavy paper as long as the proposed auger hole, and of a diameter which will easily inclose the dynamite cartridges, which are pinned through the paper in the places desired. Another method is to bind the section of the dynamite cartridges to flat strips of thin wood, such as bamboo. Old porch screens make excellent material for this purpose. Electricians' adhesive tape or insulated tape is used for fastening the parts of the dynamite cartridges at the desired intervals along the bamboo strips. This method is somewhat superior to the paper tube, in that it does not break in high winds, but requires more care in loading to keep pieces of loose earth and sand from getting between the sections of the dynamite.

A special booklet entitled "Pole and Post Hole Blasting," will be sent on request. This booklet has been prepared with great care and will be found of great value to everyone interested in road work.

## CONTROLLING FOREST FIRES WITH DYNAMITE

There are two kinds of forest fires; the overhead fire, where the flames leap from tree to tree, and the smoldering fire, which is in what is called forest duff, a deposit of dried leaves and pine needles, sometimes a foot or two deep. Of the two, the fire in the duff is perhaps more difficult to control, as it smolders for a long time under the surface, sometimes under the snow, and is difficult to detect at the distance of the observation stations, and is likely to break out in the open in several places at once.

The method heretofore adopted for controlling the latter kind of forest fire has been to dig a trench by hand. This blocks the progress of the fire and exposes sand or loam, which can be thrown as an extinguisher on the burning material. By ditching with dynamite in the forest duff, it is possible not only to cut off the progress of the fire, and expose the sand and loam, but also to blow out the forest fire, as one would blow out a candle, by the blast from the explosive gases.

The ditching operation is conducted by the electrical method, a 20 per cent. Red Cross Extra, or straight dynamite with a No. 6 electric blasting cap in each cartridge. The holes should be placed about 2 feet apart and 18 inches deep, using a punch bar to make the holes. This will usually make a ditch from 4 to 5 feet wide, 2 to 2½ feet deep, and any length desired, up to the capacity of the blasting machine. As an emergency measure, ditching across the path of a forest fire is undoubtedly a success, and an equipment of dynamite, electric blasting caps, blasting machines and leading wires, should be in the hands of every forest fire control station.

## EXCAVATING FOR BUILDING FOUNDATIONS

Dynamite is used in this work just as it is in other kinds of excavating, except that it is generally necessary to drill more and shallower holes and charge lighter because of the proximity of buildings and public thoroughfares. For additional protection from flying material the bore holes are frequently covered, before firing, with blasting mats and railroad ties. Red Cross 40 per cent. Extra Dynamite is recommended if the work is dry. If wet, Red Cross Straight Dynamite of the same strength should be used.

## RAZING BUILDINGS

Dynamite has been found of great advantage in razing buildings in the pathway of large fires or which for some other reason it is



BLASTING DOWN AN OLD RAILROAD STATION

necessary to remove quickly. Charges of 40 per cent. Red Cross Dynamite located under or against the principal supports will do the work quickly and completely. The quantity of dynamite necessary depends on the size of the support.

### BREAKING UP FROZEN ORE PILES

It is a general custom to store large quantities of ore and similar material in the open. This material is so loose that rain and snow water penetrate it even to the bottom of the piles. In cold weather the ore on the surface freezes into a solid crust several feet thick, so that it is impossible to handle it until it has been broken up. This can only be done economically and satisfactorily with dynamite. Best results will be had with comparatively heavy charges located in crevices or openings in the frozen ore. If the ore piles are on docks and not large, the charges should be reduced to prevent damage to the docks. Red Cross Extra Dynamite, of 30 per cent. to 40 per cent. strength, will usually give best results in this work.

### LOOSENING FROZEN MATERIAL IN RAILROAD CARS

Coal, ore, sand, clay, rock ballast and similar material occasionally freezes so hard in railroad cars that it is next to impossible to dislodge it. Charges consisting of a quarter or a half of a cartridge of Red Cross 40 per cent. Extra Dynamite, if located with good

judgment, will not injure the car in any way and will prove of great assistance in breaking up the material so that it can be easily handled. The charges should be loaded into holes made with crow-bar or auger, or into crevices and fired with electric blasting cap and blasting machine.

## FARMING WITH DYNAMITE

The subject of the use of explosives in agriculture—for stumps and boulder blasting, tree planting, orchard rejuvenation, sub-soiling, drainage and ditching—is so large that no attempt has been made to describe it in this book. The subject is treated at length in "The Farmer's Handbook," sent free on request.



BORING HOLE UNDER STUMP WITH DIRT AUGER. THIS CAN ALSO BE  
DONE WITH A POINTED BAR

High explosives have, from time to time, been of great advantage for purposes other than those described herein, but as these uses are not general it is unnecessary to refer to them in detail.


## **SHORTAGE AND DAMAGE IN SHIPMENTS**

All shipments from works or magazines are carefully checked by experienced shippers before they are sent out and when customers do not receive exactly what the railroad bill of lading calls for, it is probable that a part of the shipment has been lost en route. It is necessary, therefore, for us to make claim for the value of the shortage and as no claims of this nature will be recognized by the transportation companies without acknowledgment of the shortage at destination over the signature of the railroad agent at that point, we would respectfully request our customers that they always furnish us with this acknowledgment when asking us for credit covering shortages. When shortages occur in carload shipments it is necessary for us to have positive information as to whether all car seals were intact when the car arrived at destination and just what marks appeared on these seals.

In case a shipment or part of shipment arrives at destination in damaged condition, customer should decline to accept same and furnish us with railroad agent's acknowledgment in writing of the receipt of specified items in damaged condition, so that we will be enabled to recover the value of same from the transportation company.

## **UNSATISFACTORY RESULTS**

We are most jealous of the reputation of our explosives, and earnestly request all of our customers to notify us at once if they believe that the explosives are not giving the proper results. We request that we be notified and given an opportunity to investigate, even though the customer is not sure whether the poor results are due to improper usage or defective explosives. If investigation shows that the explosives were defective when delivered to customer, we will make immediate and full adjustment. In case the material was sent out in defective condition or below standard it is necessary, in order to prevent a repetition, that we trace the trouble to its source, and it is impossible for us to do this unless the defective material be set aside for our examination and test and the cases and cartons in which it was received be retained for us to inspect. In this way only can we trace the works at which the explosive was made and date of manufacture. We trust, therefore, that when trouble occurs our customers will advise us immediately and that under no circumstances will either the material itself or packages in which it was received be destroyed before the arrival of our representative.

 *A detailed description of all of the blasting supplies sold by the Du Pont Company, including instructions as to how they should be used, is given in our Blasting Supplies Catalogue, a copy of which will be gladly furnished on application.*

## PRECAUTIONS TO BE OBSERVED IN GENERAL WITH REGARD TO EXPLOSIVES

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- DON'T forget the nature of explosives, but remember that with proper care they can be handled with comparative safety.
- DON'T smoke while you are handling explosives, and don't handle explosives near an open light.
- DON'T carry loose matches in your pockets while loading explosives; use safety matches.
- DON'T shoot into explosives with a rifle or pistol either in or out of a magazine.
- DON'T allow shooting or hunting near magazines.
- DON'T leave explosives in a field or any place where stock can get at them. Cattle like the taste of the soda and saltpetre in explosives, but the other ingredients would probably make them sick or kill them.
- DON'T handle or store explosives in or near a residence.
- DON'T leave explosives in a wet or damp place. They should be kept in a suitable, dry place, under lock and key, and where children or irresponsible persons cannot get at them.
- DON'T explode a charge to chamber a bore hole and then immediately reload it, as the bore hole will be hot and the second charge may explode prematurely.
- DON'T do tamping with iron or steel bars or tools. Use only a wooden tamping stick with no metal parts.
- DON'T *force* a cartridge of explosives into a bore hole.
- DON'T have a wire carrying electric current near detonators or charged bore holes at any time except for the purpose of firing the blasts.
- DON'T explode a charge before everyone is well beyond the danger zone and protected from flying debris. Protect your supply of explosives also from danger from this source.
- DON'T hurry in seeking an explanation for the failure of a charge to explode.
- DON'T drill, bore or pick out a charge which has failed to explode. Drill and charge another bore hole at a safe distance from the missed one.

- DON'T use two kinds of explosives in the same bore hole except where one is used as a primer to detonate the other, as where dynamite is used to detonate Du Pont R. R. P. The quicker explosive may open cracks in the rock and allow the slower to blow out through these cracks, doing little or no work.
- DON'T use a permissible explosive and another kind of explosive in the same bore hole, or two kinds of permissible explosives in one hole, or attempt to explode a permissible explosive with anything except a No. 6 or stronger detonator.
- DON'T use frozen or chilled explosives. Dynamite other than the low-freezing kind often freezes at a temperature between 45° F. and 50° F.
- DON'T use any arrangement for thawing dynamite other than one of those recommended by the DU PONT COMPANY.
- DON'T thaw dynamite on heated stoves, rocks, bricks or metal, or in an oven, and don't thaw dynamite in front of, near or over a steam boiler or fire of any kind.
- DON'T take dynamite into or near a blacksmith shop or near a forge on open work.
- DON'T put dynamite on shelves or anything else directly over steam or hot water pipes or other heated metal surface.
- DON'T cut or break a dynamite cartridge while it is frozen, and don't rub a cartridge of dynamite in the hands to complete thawing.
- DON'T heat a thawing house with pipes containing steam under pressure.
- DON'T place a hot water thawer over a fire, and never put dynamite into hot water or allow it to come in contact with steam.
- DON'T allow thawed dynamite to remain exposed to low temperature, but use as soon as possible.
- DON'T paint roof black.
- DON'T expose high explosives or detonators to direct rays of sun longer than necessary.
- DON'T allow priming (the placing of a blasting cap or electric blasting cap in dynamite) to be done in a thawing house.

- DON'T prime or connect charges for electric firing during the approach or progress of a thunder storm. If already primed keep everybody away until the storm is over.
- DON'T carry blasting caps or electric blasting caps in your pocket.
- DON'T tamper with, pick at or otherwise investigate a blasting cap or electric blasting cap.
- DON'T attempt to take blasting caps from the box by inserting a wire, nail or other sharp instrument.
- DON'T try to withdraw the wires from an electric blasting cap.
- DON'T fasten a blasting cap to the fuse with the teeth or by flattening it with a knife—use a cap crimper.
- DON'T keep electric blasting caps, blasting machines or blasting caps in a damp place.
- DON'T leave the leading wires connected to the blasting machine. Disconnect them immediately if necessary to return to the shot.
- DON'T loop or tie the wire connections. Scrape the ends of the wires clean and bright and twist them tightly together.
- DON'T drag the leading wires around; always coil them up and carry them.
- DON'T allow the wires of an electric blasting cap to become tangled or kinked.
- DON'T insert blasting cap or electric blasting cap in explosive cartridges carelessly. Have closed end of detonator point toward the bulk of the charge and have it tied to the cartridge securely.
- DON'T store or transport blasting caps or electric blasting caps with high explosives.
- DON'T attempt to use electric blasting caps with the regular insulation in very wet work. For this purpose secure Du Pont "Waterproof" or "Submarine" electric blasting caps.
- DON'T worry along with old, broken leading wire or connecting wire. A new supply won't cost much and will pay for itself many times over.
- DON'T handle fuse carelessly in cold weather, for when cold it is stiff and breaks easily and should be warmed slightly before using.

- DON'T store fuse in a hot place, as this may dry it out so that uncoiling will break it.
- DON'T lace fuse through dynamite cartridges, and don't place several slit or broken cartridges on top of primer with cap and fuse. This practice is frequently responsible for the burning of the charge.
- DON'T cut the fuse short to save time. It is dangerous and wasteful of explosive, as it is impossible to tamp such charges properly.
- DON'T operate blasting machines half-heartedly. They are built to be operated with full force. They must be kept clean and dry.
- DON'T expect a cheap article to give as good results as a high-grade one.
- DON'T expect explosives to do good work if you try to explode them with a detonator weaker than a No. 6 (red label).

## GLOSSARY OF TERMS USED IN THE EXPLOSIVES INDUSTRY

*Air Shot.*—The method of loading in which an air space is purposely left in contact with the explosive, for the purpose of lessening its shattering effect.

*Adobe or 'Doby.*—See "Mudcap."

*Back Holes.*—In shaft sinking or raising, the round of holes which are shot last.

*Bag.*—A paper container 1 to 2 inches diameter and 8 to 18 inches long, used for placing an inert material such as sand, clay, etc., into a bore hole for stemming or tamping, called a tamping bag.

A paper container holding 12½ pounds of Du Pont R. R. P.

*Barricade.*—An artificial mound of earth, usually as high as the eaves of a magazine roof, erected to deflect the force of an explosion upward and to protect the building enclosed from flying objects.

*Battery.*—See "Blasting Machine."

*Blasting Barrel.*—A piece of iron pipe, usually about ½ inch in diameter, used to provide a smooth passageway for the miner's squib. It is recovered after each blast and used until destroyed.

*Blasting Cap.*—A copper shell closed at one end and containing a charge of detonating compound, which is ignited from the spark of the fuse, used for detonating high explosives.

*Blasting Circuit.*—The leading wires, connecting wires and connected electric blasting caps, when prepared for the firing of a blast.

*Blasting Gelatin.*—A high explosive, consisting of nitroglycerin and nitro cotton. It is the strongest explosive known, and is a rubber-like, elastic substance, unaffected by water.

*Blasting Machine.*—A portable dynamo, in which the armature is rotated by the downward thrust of the rack bar or handle, used for firing blasts electrically.

*Blasting Mat.*—A tightly woven covering of heavy manila rope or wire rope, or chain, made in various sizes, for covering the material to be blasted and preventing the flying of small fragments of rock.

*Blasting Powder.*—A variety of gunpowder, made from saltpetre or Chili saltpetre, charcoal and sulphur, formed into grains of uniform size, used for blasting.

*Blasting Supplies.*—A term used to include electric blasting caps, ordinary blasting caps, fuse, blasting machines, galvanometers, rheostats, etc., in fact, everything used in blasting, except explosives.

*Blistering.*—See "Mudcap."

*Block Hole.*—A small hole drilled in a block of rock either by hand drill or a portable air drill, to contain small charges of explosives.

A relief hole, designed to remove part of the burden from a subsequent shot, used in coal mining.

*Blow-out.*—A blast which fails to dislodge the material desired and spends all its force in blowing out the tamping through the bore hole.

*Bore Hole.*—A hole bored in the rock, coal, ore or other material, into which explosives are loaded for blasting the material away from its original position.

*Bottom.*—To break the material and throw it clear from the bottom or toe of the bore hole.

*Breaking-in Shot.*—The first bore hole fired in blasting off the solid or to provide a space into which material from subsequent shots may be thrown.

*Breast Holes.*—Relief holes used in tunneling which are fired after the bottom cut.

*Brushing Shot.*—A charge fired in the air of a mine to blow out obnoxious gases, or to start an air current.

*Bridge Wire.*—The fine platinum wire which is heated by the passage of an electric current to ignite the priming charge of an electric blasting cap or an electric squib or similar devices.

*Bug Dust.*—The fine coal or other material resulting from a boring or cutting of a drill, sometimes wrongly used as a tamping or stemming material in coal mining.

*Bulldoze.*—See "Mudcap."

*Burden.*—The distance between the charge and the free face of the material to be blasted.

*Buster Shot.*—Same as "Breaking-in Shot."

*Butt Shot.*—In coal mining a charge placed so that the face or burden is nearly parallel to the bore hole.

*Cap.*—See "Blasting Cap."

*Cap Crimper.*—See "Crimper."

*Carbonite.*—A permissible explosive characterized by a short flame and low velocity of detonation which withstands water fairly well.

*Carlton*.—A pasteboard box containing high explosives, blasting caps or electric blasting caps, a number of which are packed in a wooden case for shipment.

*Cartridge*.—A cylindrical waterproof paper shell, filled with high explosive and closed at both ends.

*Case*.—A wooden box in which dynamite is shipped.

A wooden box in which cartons of electric blasting caps, boxes of blasting caps or coils of fuse are shipped.

*Case Markings*.—The letters or figures stenciled or printed on the front of a case containing explosives indicating the size, weight, kind, strength, date, and place of manufacture.

*Center Cut*.—The bore holes drilled to include a wedge-shaped piece of rock which are fired first in the heading of a tunnel.

*Chamber*.—See "Springing."

*Charge*.—The explosive loaded into a bore hole for blasting; also any unit of an explosive, as a charge of nitroglycerin or a charge of detonating composition in the blasting cap.

*Charging*.—The loading of a bore hole with explosives.

*Chilled*.—The condition of the dynamite when subjected to a low temperature not sufficient to congeal it, but which seriously affects the strength of the dynamite.

*Churn Drill*.—See "Well Drill," also a hand-operated drill with a cutting bit on either end and a weight welded at the center, operated by lifting and dropping of its own weight against the rock to be drilled.

*Collar*.—The mouth or opening of a bore hole.

*Combination Shot*.—A blast made by dynamite and permissibles or permissible explosives and blasting powder in the same hole. It is bad practice and in many states is prohibited by law.

*Connecting*.—The operation of joining adjacent electric blasting cap wires to each other, to connecting wire and to the leading wires, in such a way that an electric current will flow through with the least possible resistance.

*Connecting Wire*.—A wire of smaller gauge than the leading wire used for connecting the electric blasting cap wires from one bore hole to those of an adjoining one.

*Coyote Hole*.—Same as gopher hole. A tunnel of small size, usually just large enough to admit a man, driven into the solid rock and charged with an explosive for blasting. It is driven horizontally into the rock at right angles to the face of the quarry and has two or more cross-cuts driven from it parallel to the face. It is in the ends of these cross-cuts that the explosive charge is generally placed, and the remaining space in the tunnel is filled up with rock, sand, timbers or concrete, to act as stemming or tamping.

*Crimp*.—The flattening made near the mouth of a blasting cap for holding the fuse in place.

*Crimper*.—An instrument for making the crimp.

*Cut Holes*.—The first round of holes fired in a tunnel or shaft.

*Delay Electric Blasting Cap*.—A detonating device with a delay element between the priming and detonating composition. It detonates about one or two seconds after the electric current has passed through the bridge. They are made in two kinds—First and Second Delay—and are used in connection with regular, waterproof or submarine electric blasting caps for blasting in tunnels, shafts, etc., where it is desirable to have charges fired in succession without the necessity of the blaster returning between the blasts.

*Delay Electric Igniter*.—An electrical device using fuse as the delay element by which it is possible with the use of a blasting cap on each fuse to detonate a number of charges in succession.

*Detonation*.—The conversion of a solid into gases with extreme rapidity, as in the case of high explosives like dynamite.

*Detonator*.—A term used to include blasting caps and electric blasting caps, or any device used for detonating a high explosive.

*Ditching*.—The digging or making of a ditch by the use of explosives. See "Propagated Blast."

*Ditch Wiring*.—The method of connecting electric blasting caps in such a way that the two free ends can be connected at one end of the line of holes.

*Doby*.—See "Mudcap."

*Dope*.—The absorbent or active base of a dynamite.

*Double Load*.—A load in a bore hole separated by a quantity of inert material for the purpose of distributing the effect, or for preventing part of the charge blowing out at a seam or fissure, in which case the inert material is placed so as to include the seam.

*Duck's Nest*.—See "Springing."

*Dummy*.—A paper bag filled with sand, clay, etc., for tamping or for separating two charges in a double-loaded bore hole.

*Duplex Wire*.—Two insulated copper leading wires wrapped with paraffined cotton covering together.

*Du Pont R. R. P.*—An explosive intermediate between blasting powder and dynamite, and partaking somewhat of the character of both. It is a black substance containing sulphur, charcoal or coal, and nitrate of soda, formed into non-porous grains and mixed with nitroglycerin.

*Dynamite*.—Originally, an explosive made of 75 per cent. nitroglycerin absorbed in 25 per cent. Kieselguhr; now, any high explosive containing explosive ingredients used for blasting purposes.

*Electric Blasting Cap*.—A device for detonating charges of explosives electrically. It consists essentially of a blasting cap, into the charge of which a fine platinum wire is stretched across two protruding copper wires, the whole fastened in place by a composition sulphur plug. The heating of the platinum wire bridge by the electric current ignites the explosive charge in the cap, which in turn detonates the high explosive.

*Electric Blasting*.—The firing of one or more charges electrically, whether electric blasting caps, electric squibs, or other electric igniting or exploding devices are used.

*Electric Exploder*.—A former designation for electric blasting cap.

*Electric Detonator*.—The term used in England and in Canada for electric blasting cap.

*Electric Squib*.—A device similar to an electric blasting cap, but containing a gunpowder composition which simply ignites but does not detonate an explosive charge, used for electric firing of blasting powder.

*Exploder*.—The term used in England to designate an electric blasting machine.

*Explosive*.—Any mixture or chemical compound that may explode by sudden combustion or decomposition.

*Extra Dynamite*.—The present designation of those explosives consisting of nitroglycerin, other explosive ingredients and an active base absorbent. They are more easily affected by water than straight dynamites, but give off less noxious fumes, are less sensitive to blows, and they ignite less easily from sparks than straight dynamite.

*Face*.—The free surface, generally more or less vertical, of a quarry or mine or tunnel heading.

*Firing Machine*.—A designation for the electric blasting machine.

*Follow-up Tag*.—The cardboard tag placed in the cartons, boxes or cases of blasting supplies, used for identifying the date and place of manufacture.

*Flogging a Squib*.—Uncoiling the end of the paper which is impregnated with sulphur or some other combustible substance. Flagging the squib permits more time to elapse from the ignition of the unrolled paper and the firing of the charge of powder.

*Flat Cut*.—A manner of placing the bore holes for the first shot in the tunnel in which they are started about 2 or 3 feet above the floor and pointed downward so that the bottom of the hole shall be at about level with the floor.

*Front*.—A designation for the mouth or collar of a bore hole.

*Fulminate*.—A common designation for fulminate of mercury. The principal explosive ingredient in the ordinary detonators. It is an exceedingly sensitive substance and when ignited by means of a hot wire or spark from a fuse, it explodes with very great suddenness. It is used practically only for detonating high explosives.

*Fumes*.—The gases and smoke, more especially the noxious or poisonous gases given off by the explosion or detonation of blasting powder or dynamite.

The character of the fumes is influenced largely by the completeness of detonation; therefore, the degree of confinement of the charge and the size of the detonator has a great influence in the character of the fumes produced.

*Fuse*.—A core of black powder wrapped with hemp or cotton threads or tape, with various water-proofing compounds between each, or on the outside, to provide a uniform burning speed of the powder core for the firing of explosives, either with or without a blasting cap. Fuse usually burns at the rate of about 2 feet per minute, and is made in various grades, depending on the amount of water they are required to withstand.

*Fuse Lighter*.—A device for facilitating the ignition of the powder core of a fuse. One form is in the shape of a carpet tack covered with a powder composition; another form is in the shape of a cord, which when ignited, burns and maintains a "coal of fire" which may be touched to the exposed powder in the fuse.

*Fuze*.—Pronounced as though spelled "fuzee." Originally the device used for exploding the bursting charge in a projectile and later used as a designation for an electric blasting cap. Now known as an electric blasting cap.

*Galvanometer*.—Strictly speaking, a galvanometer is an instrument for determining the presence of an electric current. The Du Pont Galvanometer consists of a galvanometer, resistance

coil and source of current, and is really a direct reading ohmmeter, and is used for determining the resistance of a blasting circuit.

*Gelatin Dynamite*.—A high explosive consisting of nitroglycerin and guncotton, made into a jelly with which is mixed the absorbent or active base. It is a plastic, water-proof high explosive, of high density, used principally for close work and where it is exposed to water.

*Gelignite*.—The term by which gelatin dynamite is known abroad.

*Granulation*.—The sizes into which the particles of blasting powder are separated for uniformity.

*Gob*.—The waste, rock in coal and other mines which is left in the mines, usually piled up between the different rooms or headings.

*Gopher Hole*.—Same as a coyote hole. It is sometimes used as a designation for any horizontally drilled hole, usually on a level with the quarry floor.

*Grade*.—The degree of strength of a high explosive. Those above 40 per cent. are arbitrarily designated as "high" grade and those below 40 per cent. strength as "low" grade dynamites.

*Guhr*.—See "Kieselguhr."

*Gun*.—A bore hole in which the charge of explosive has been fired with no other effect than to blast off a small amount of material at the mouth of the bore hole; also called a boot-leg or "John 'Odges."

*Guncotton*.—A nitro-cotton of the highest nitration or containing the greatest possible percentage of nitrogen. Sometimes called insoluble cotton. It is used as a bursting charge for submarine mines and for demolishing bridges and other structures in warfare.

*Hang-Fire*.—Condition where a charge explodes later than expected. A hang-fire rarely occurs with electric firing, but is not infrequent with blasting cap and fuse.

*Heel*.—The mouth or collar of a bore hole.

*High Explosives*.—Explosives which detonate or composed of ingredients which detonate. In the United States the designation covers explosives like gelatin, dynamite, blasting gelatin, etc.

*High Grade*.—An arbitrary designation of dynamite of 40 per cent. strength or over. See "Grade."

*Hobo Connections*.—See "Parallel Connections."

*John 'Odges*.—See "Gun."

*Keg*.—A cylindrical container made of steel or some other substance, which contains 25 pounds of blasting powder or gun powder.

*Kettle*.—See "Thawing Kettle."

*Kieselguhr*.—An absorbent earth composed of the calcined skeletons of fossil diatoms. It was formerly used as the only absorbent for nitroglycerin in the original dynamite. It is an inert substance or passive base, whose only value lies in its capacity to absorb about three times its weight in nitroglycerin.

*Leading Wire*.—A cotton-covered copper wire, usually No. 14 gauge, used for connecting the two free ends of the circuit of the electric blasting caps in the blast to the blasting machine.

*Legs*.—The wires attached to and forming a part of an electric blasting cap.

*Lifters*.—Bore holes for blasting which are drilled horizontally or nearly so and usually at about the floor level.

*Low Explosives*.—A term sometimes used to designate explosives which do not detonate, like blasting powder, in distinction to high explosives, such as dynamite.

*Low-Freezing Dynamite*.—A dynamite so made that its freezing point is below that of the dynamites containing nothing except nitroglycerin and an active base which have a normal freezing point of about 45°. Low-freezing dynamites do not freeze until temperatures below 32° F. are reached, and even then only after prolonged exposure.

*Low Grade*.—An arbitrary designation of dynamites of less strength than 40 per cent. It has no bearing on the quality of the materials, as they are of as great purity and high quality as the ingredients in a so-called "high grade" explosive.

*Low Powders*.—Explosives containing a small proportion of nitroglycerin and a base similar to blasting powder. Intermediate between blasting powder and dynamite in action.

*Misfire*.—The failure of a charge to explode when expected. In electric firing it is generally due to broken circuit or insufficient current. If the electric blasting cap fires without exploding the charge, it is usually due to misplaced detonator or the charge has been affected by storage in a wet place. Misfires with fuse and blasting caps are generally due to the fuse going out or to the failure of the fuse to ignite the blasting cap. Failure of the blasting cap to detonate the dynamite, when it is fired, is usually due to its having been affected by dampness.

*Monobel*.—A permissible explosive characterized by the production of a short flame, low temperature and velocity of detonation. There is very little smoke from the explosion of Monobel and practically no poisonous fumes.

**Mudcap.**—A charge of dynamite or other high explosive fired in contact with the surface of a rock after being covered with a quantity of wet mud, wet earth or sand, no bore hole being used. The slight confinement given the dynamite by the mud or other material permits part of the energy of the dynamite being transmitted to the rock in the form of a blow. A mudcap may be placed on top or to one side, or even under a rock, if supported, with equal effect.

**Nitro-Cellulose.**—A term used to include the various nitrates of cellulose, such as gun-cotton, nitro-lignine, nitro-cotton, nitro-jute, etc. The most common of these is nitro-cotton.

**Nitro-Cotton.**—A chemical combination of ordinary cotton fibre with nitric acid. It is explosive, highly inflammable and in certain degrees of nitration, soluble in nitroglycerin.

**Nitroglycerin.**—A chemical combination of glycerin and nitric acid. It is an oily substance about one and one-half times as heavy as water (SP.GR.1.6), is almost insoluble in water, and is used as a principal or active ingredient in dynamite, gelatin dynamite, etc. It is not used commercially in the form of a liquid, except for "shooting" oil wells.

**Needle.**—A piece of copper or brass about  $\frac{1}{2}$  inch in diameter and 3 or 4 feet long, pointed at one end, and turned into a handle at the other, tapering from the handle to the point. It is thrust into a charge of blasting powder in a bore hole, and while in this position the bore hole is tamped up solid, preferably with moist clay. The needle is then withdrawn carefully, leaving a straight passageway through the tamping for the miners' squib to shoot to fire the charge.

**Pasting.**—The operation of mudcapping.

**Permissible Explosives.**—Explosives which have passed certain prescribed tests by the Bureau of Mines of the Department of the Interior, of the United States Government, which are not likely to cause ignition of mine gases, coal dust or a mixture of the two, for use in coal mines. The government does not require the use of permissible explosives, but only recommends same for use in gaseous and dusty mines.

**Plastering.**—Same as "Mudcapping."

**Plug Hole.**—Same as "Block Hole."

**Point.**—The end or bottom of a bore hole, as distinguished from the mouth or collar.

**Pop Shot.**—Same as "Block Hole Shot."

**Primer.**—A dynamite cartridge or package of any explosive, which contains the detonator, whether blasting cap or electric blasting cap.

**Priming.**—The operation of inserting a detonator into a cartridge of explosive and fastening it thereto.

**Propagated Blast.**—A blast consisting of a number of unprimed charges of explosives and only one hole primed, generally for the purpose of ditching, where each charge is detonated by the explosion of the adjacent one, the shock being transmitted through the wet soil. In this method, one detonator fired in the middle of a line of holes is capable of bringing about the explosion of several hundred such charges.

**Quickness.**—The property of an explosive by virtue of which it exerts a sharp blow or shattering effect on the material with which it is in contact. The quickest explosive of the dynamite class is the 60 per cent. straight dynamite. Quick explosives are the ones particularly desired for mudcapping. For maximum effect for this purpose, they should be of high density and sensitiveness.

**R. R. P.**—Railroad powder. An explosive consisting of assorted size grains of an explosive somewhat similar to gunpowder, made in such a way that the grains are not porous, having nitroglycerin on the surface not absorbed by the grain. See "Du Pont R. R. P."

**Red Cross Explosives.**—A class of high explosives manufactured by the Du Pont Company in the gelatin straight and extra grades, characterized by the low-freezing point.

**Reel.**—A device for winding leading wire for avoiding kinking and breaking the wire, and for keeping it in good condition.

**Relief Holes.**—Bore holes, which are loaded and fired for the purpose of relieving or removing part of the burden of the charges to be fired in the main blast.

**Rheostat.**—An instrument for inserting varying resistance in an electric circuit for controlling the intensity of an electric current. The Du Pont rheostat is an instrument for testing blasting machines by inserting definite resistance equal to a known number of electric blasting caps of a standard length wire, using one electric blasting cap as an indicator.

**Rib Shots.**—The shots fired in holes drilled next to the sides of the room or tunnel. In mining or tunneling, the rib is that portion of the material to be blasted corresponding to the side walls of a room.

**Saltpetre.**—Nitrate of potash. The principal ingredient in "A" blasting powder.

**Sand Blast.**—A mudcap in which sand is used instead of mud.

**Sensitiveness.**—The property in a high explosive, which permits it to be exploded by a shock. The more insensitive an explosive is, the stronger detonator it requires to develop the full strength.

**Scrapping.**—The breaking up of metal castings, plate, etc., with explosives, generally by muddcapping.

**Shaking.**—The same as "Springing."

**Short Fuse.**—The practice of firing a blast, the fuse on the primer of which is not sufficiently long to reach from the top of the charge to the collar of the bore hole. The primer is loaded while the fuse is burning and tamping may, or may not, be attempted. It is an exceedingly dangerous practice.

**Short Leg.**—The wires on an electric blasting cap, one of which has been shortened so that when loaded in the bore hole, the two splices or connections will not come opposite each other and make a short circuit.

**Side-Spit.**—The emission of sparks through the sides of a burning fuse.

**Snake Hole.**—A bore hole driven horizontally or nearly so and approximately on a level with the quarry floor; also a bore hole driven under a boulder for containing a charge of explosives. In quarry work it is called a "lifter."

**Socketing.**—Same as "Springing."

**Spitting.**—Lighting the fuse.

**Springing.**—The enlarging of a bore hole at the bottom by the successive firing of increased charges of explosives, usually a quick-acting dynamite. The number of times that a hole must be sprung to give the desired result can only be determined by experiment.

**Squib.**—A paper tube filled with a powder composition which, when lighted at one end, burns for a few seconds then ignites the powder composition and shoots like a rocket through the bore hole or through a blasting barrel placed in the bore hole into the charge of blasting powder which it ignites. Used principally in coal mining.

**Squib Shot.**—A blast with a small quantity of high explosives fired at some point in the bore hole for the purpose of dislodging some foreign material which has fallen into it.

**Squibbing.**—See "Squib Shot."

**Stemming.**—Term used by the Bureau of Mines to designate the inert material used for confining the force of an explosive and also for the process of placing this material in the bore hole, same as tamping.

**Storage.**—The keeping of explosives in a magazine.

**Straight Dynamite.**—A high explosive made in strength from 20 to 60 per cent., consisting essentially of nitroglycerin and an active base or absorbent.

**Submarine Blast.**—Firing of high explosives in bore holes drilled in the rock under water for the sake of dislodging dangerous projections and deepening channels.

**Subsoiling.**—The firing of small charges of dynamite 2 or 3 feet below the surface for breaking up impervious strata of soil, clay, etc., for aerating, draining and moistening the soil.

**Tamping.**—Term used in the United States to designate the material used for confining charges of explosives in bore holes, the placing of the material and packing of it in the bore hole, and in some sections, the packing of the high explosives in the bore hole. This latter is not a desirable definition.

**Thawing.**—The warming of frozen dynamite to a point where it becomes soft and plastic. It should be done carefully, slowly and according to directions issued by the manufacturers of the explosives.

**Thawing Kettle.**—A double kettle, built somewhat like a farina boiler, having two compartments, an outer compartment, which is filled with hot water and which entirely surrounds the inner compartment which contains the dynamite to be thawed. It is provided with a lid for holding the heat.

**Thawing House.**—A small building, designed for thawing dynamite of such size as to provide enough thawed dynamite for the day's work. Thawing houses should be heated either with hot water or exhaust steam in such a manner that the explosives cannot come in contact with the heated metal or lie directly over the heated metal.

**Toe.**—The burden of material between the bottom of the bore hole and the free face. It is sometimes used to designate the bottom of the bore hole itself as distinguished from the heel, collar or mouth of the bore hole, which is the open end.

**Transportation.**—The moving of explosives from distributing point to magazine and from magazine to thawing house or point of consumption.

**Tunneling.**—The driving of a tunnel which is to be used for the passage of railroad trains, etc., or the driving of a bore in rock which is afterwards filled with explosives in large quantities, similar to a bore hole, on a large scale, except that the tunnel is usually drilled directly into the face of the rock for several feet, then divided in two parts on the same level at right angles to the first tunnel forming in plan a "T," the ends of which are filled with explosives and the intermediate parts filled with inert material like an ordinary bore hole.

*Undercut.*—A term used in coal, and some other kinds of mining, to designate a cutting out by mechanical means of a portion of the material to be removed in order to facilitate blasting operation. It is usually done on the level of the floor of the mine, extending laterally the entire face and 5 or 6 feet into the material.

*V-Cut.*—In mining and tunneling a cut where the material blasted out in plan is like the letter "V"; usually consists of six or eight holes drilled into the face, half of which forms an acute angle with the other half.

*Velocity of Detonation.*—The velocity with which the detonation or explosion of a mass of explosives travels through the mass itself.

*Well-Drill Holes.*—Holes drilled by means of an apparatus known as the well drill, or similar to that, and used for blasting on comparatively large scale. Such holes are usually 5 or 6 inches in diameter and from 30 to 150 feet deep.

*Well Shooting.*—The firing of a charge of nitroglycerin, or other high explosive, in the bottom of a well for the purpose of increasing the flow of water, oil or gas.

*Well Sinking.*—The driving of a well, usually over 3 or 4 feet in diameter, to a depth not exceeding 30 or 40 feet.

*Windy Shot.*—A blast in coal mines which, due to improperly placed charges, wrong kind of explosives, or insufficient tamping, ignites a gas mixture, causing a secondary explosion which may or may not spread throughout the mine.

THIS High Explosives Handbook is printed in two sections, this being Section 1.

Section 2 covers kinds, grades and brands of Du Pont High Explosives.

Should you not already have Section 2, a copy will be sent on request.

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